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Instructional strategies in science classrooms of specialized secondary schools for the gifted

Donna Lorraine Poland
William & Mary - School of Education

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**INSTRUCTIONAL STRATEGIES IN SCIENCE CLASSROOMS
OF
SPECIALIZED SECONDARY SCHOOLS
FOR THE GIFTED**

A Dissertation

Presented to

The Faculty of the School of Education

The College of William and Mary

In Partial Fulfillment

Of the Requirements for the Degree

Doctor of Philosophy

by

Donna Lorraine Poland

April 2003

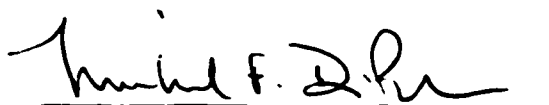
**INSTRUCTIONAL STRATEGIES IN SCIENCE CLASSROOMS
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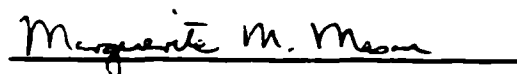
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DEDICATION

This dissertation is dedicated to my family,

Michael, Caitlin and Matthew,

whose love, encouragement, support and cooperation

allowed me to accomplish this goal,

and to my parents,

Frank and Mary Jackson,

who have been pillars of support throughout my life.

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INSTRUCTIONAL STRATEGIES IN SCIENCE CLASSROOMS OF SPECIALIZED SECONDARY SCHOOLS FOR THE GIFTED

ABSTRACT

This study examined the extent to which science teachers in Academic Year Governor's Schools were adhering to the national standards for suggested science instruction and providing an appropriate learning environment for gifted learners.

The study asked 13 directors, 54 instructors of advanced science courses, and 1190 students of advanced science courses in 13 Academic Year Governor's Schools in Virginia to respond to researcher-developed surveys and to participate in classroom observations. The surveys and classroom observations collected demographic data as well as instructors' and students' perceptions of the use of various instructional strategies related to national science reform and gifted education recommendations. Chi-square analyses were used to ascertain significant differences between instructors' and students' perceptions.

Findings indicated that instructors of advanced science classes in secondary schools for the gifted are implementing nationally recognized gifted education and science education instructional strategies with less frequency than desired. Both

students and instructors concur that these strategies are being implemented in the classroom setting, and both concur as to the frequency with which the implementation occurs. There was no significant difference between instructors' and students' perceptions of the frequency of implementation of instructional strategies. Unfortunately, there was not a single strategy that students and teachers felt was being implemented on a weekly or daily basis across 90% of the sampled classrooms. Staff development in gifted education was found to be minimal as an ongoing practice.

While this study offers some insights into the frequency of strategy usage, the study needs more classroom observations to support findings; an area of needed future research. While this study was conducted at the secondary level, research into instructional practices at the middle school and elementary school gifted science classroom settings would be appropriate and warranted.

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SCHOOL OF EDUCATION: DOCTOR OF EDUCATIONAL POLICY PLANNING

AND LEADERSHIP WITH AN EMPHASIS IN GIFTED EDUCATION

THE COLLEGE OF WILLIAM AND MARY IN VIRGINIA

**INSTRUCTIONAL STRATEGIES IN SCIENCE CLASSROOMS
OF
SPECIALIZED SECONDARY SCHOOLS
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CHAPTER 1

INTRODUCTION

Introduction to the Study: The National and International Picture

Over the past decades, international comparisons of students in science achievement have consistently seen U.S. students academically ranked near the bottom among industrialized nations. Even our top ten percent of academically performing students were ranked towards the bottom when compared to similar groups of students in other industrialized nations, especially in the areas of higher order thinking skills, mathematics, and science (Office of Educational Research and Improvement, 1993; U.S. Department of Education, 1990). More specifically, international comparisons in science show students obtaining scores near or slightly above the overall international average; yet still achieving an international ranking in science below many industrialized nations (National Center for Education Statistics, 1996).

The *National Excellence* report (Office of Educational Research and Improvement, 1993) further illuminates the inadequacies of our educational system to support its brightest students in academic endeavors. Among an extensive list of educational issues, the report highlights that teachers use few, if any, higher-level teaching strategies in their classrooms to accommodate gifted learners.

While the *National Excellence* (OERI, 1993) report focuses on the need for teachers to use complex instructional strategies to meet the academic needs of gifted learners, the Third International Mathematics Science Study (TIMSS) (National Center for Education Statistics, 1996) stresses the need for teachers to implement instructional strategies in keeping with reform recommendations in science and mathematics. These recommendations include instructional strategies that emphasize concept attainment, hands-on applications, inquiry-based science, and real world connections; strategies similar to the complex instructional strategies recommended for gifted learners. National science standards recognize the need for these instructional strategies to be implemented, along with other components, for effective science teaching, the heart of science education reform (National Research Council, 1996).

In curriculum design, the focus of science education reform efforts has been to advocate for world-class standards in science learning, science instruction, and science curriculum (American Association for the Advancement of Science, 1990; American Association for the Advancement of Science, 1989; Rutherford and Ahlgren, 1989). Initiatives in science standards, such as the National Science Education Standards (NRC, 1996) and Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993), have set an ambitious agenda

for a comprehensive general science education for all students. The approaches to science education suggested by these documents stress the need for effective curricula and instructional strategies that incorporate essential scientific knowledge, concepts, and processes deemed necessary to foster science literacy. Additional emphasis is placed on investigating and analyzing scientific questions from various social and interdisciplinary perspectives, the utilization of technology and inquiry in instruction and learning, and an understanding of the history and nature of science (NRC, 1996).

Study Context

The Virginia Department of Education (VDOE) regulations mandate differentiated instructional opportunities for gifted students. The VDOE, in conjunction with localities, established regional 'joint schools' to serve the needs of high school gifted students. The concept of Governor's Schools was established in 1973 with four summer programs serving 400 gifted students, and has grown to 21 programs serving 6,500 students throughout the Commonwealth. Each summer or academic year school has developed a unique program to serve the needs of the high school gifted students throughout their region, providing acceleration and

exploration into areas ranging from the performing arts and global economics, to government and science and technology.

With the unqualified success of the summer Governor's School programs, the first four Academic Year Governor's Schools (AYGS) were founded in 1985.

Currently, there are 15 AYGS across the Commonwealth of Virginia. AYGS vary in the format through which services are offered to students. While most schools are shared time programs serving gifted students for only a portion of the school day, three schools provide full-day programs that meet state requirements for graduation. Amongst the shared time program schools, two schools (virtual Governor's Schools) serve students via distance learning Internet connections (Virginia Department of Education, 2002).

The Academic Year Governor's Schools' courses and programs are designed to stress non-traditional teaching and learning techniques. Inquiry learning, hands-on experiences, research opportunities, field studies, and the utilization of technology as an integral part of the curriculum are key components of Governor's Schools' instruction and curriculum. Academic Year Governor's Schools serve a vital role in the provision of mandated instructional opportunities for gifted learners (Virginia Department of Education, 1996). Thus, they represent an excellent context within

which to study the enactment of science reform and gifted education best practices at the secondary level.

To provide a more productive science learning environment that incorporates new standards for all aspects of science education, educators must reexamine their science curricula and instructional approaches to learning. Similarly, educators of gifted students must continually reexamine their curriculum to address instructional and curricular practices in keeping with the field of gifted education. For secondary science teachers of gifted students, the task of providing courses that incorporate the recommendations in both the fields of science education and gifted education is doubly critical. Many of the recommendations from both of these fields of education overlap. However, to ensure that these recommendations are being incorporated for Virginia's gifted, high school science students, a closer examination of classroom instruction at Academic Year Governor's Schools is warranted.

Problem Statement

Now that numerous reports and reform recommendations in both the fields of science education and gifted education have been in existence for several years, are specialized secondary schools for the gifted in Virginia embracing instructional science reform initiatives in combination with addressing the needs of our most

academically talented student population? In attempting to answer this question, this study explored comparisons among science teachers as they relate to the program design, the professional background of teachers, the professional development of teachers, and classroom observations of science instruction at various Academic Year Governor's Schools across the Commonwealth of Virginia. In addition, teacher and student perceptions regarding teacher implementation of both science reform initiatives and gifted education curriculum standards were examined.

Definition of Terms

The following definition of terms will apply to the research:

Constructivism - A philosophical view on how individuals come to know or understand; through interactions with their environment, through cognitive conflicts that serve as stimuli for learning and as organizers of information, and through evolving individual understanding as a result of social negotiation (Savery & Duffy, 1995). Constructivism "construes learning as an interpretive, recursive, building process by active learners interacting with the physical and social world (Fosnot, 1996, p. 30)."

Differentiation - The deliberate modification of curriculum and instructional strategies to meet the specific educational needs of student learners. For gifted

learners, differentiation should include content depth and complexity, appropriate instructional pacing, process goals and products associated with the content, and concept development related to themes and issues (VanTassel-Baska, 1994; VanTassel-Baska, 1992).

Gifted - In terms of students accepted in Academic Year Governor's Schools, a gifted student would be represented by someone who successfully met the multiple criteria standards that were set and reviewed by trained evaluators experienced in gifted education and the focus area of their specific AYGS. Since AYGS are independent, admission requirements and procedures may vary from school to school. Students typically have excellent academic records for advanced courses, score high on standardized tests (*i.e.*, PSAT, SAT, Stanford 9, ITBS, VA State SOLS), successfully answer interview questions or write an original essay, have honors and/or awards, and have favorable recommendations from multiple sources (Virginia Department of Education, 2002).

Hands-on instruction - Instruction that promotes student learning through the use of instructional approaches that favor active student involvement over passive learning. In science, such approaches could involve experimentation, investigation (American Association for the Advancement of Science, 2000), observation and measurement (Ruby, 2001).

Higher-Level Thinking - Students' cognitive processes that involves application of knowledge to new areas, analysis and synthesis of concepts and knowledge, and evaluation of information. These higher levels of Bloom's Taxonomy of Cognitive Behaviors involve the integration of basic knowledge and comprehension into a more complex thinking structure, taking into account multiple variables of information and perceptions. These higher order thinking skills are characteristic steps in the process of constructing knowledge (Yager, 1996).

Instructional Strategies - A variety of techniques teachers use to impart knowledge and facilitate learning in students. Teachers use instructional strategies to "help students acquire information, ideas, skills, values, ways of thinking, and means of expressing themselves," and, ultimately, as "a way of teaching students how to learn (Joyce, Weil, and Showers, 1992, p. 1)."

Inquiry - Scientific inquiry refers to the many ways in which scientists know the natural world and examine evidence to explain natural relationships. For science students, "inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry

requires identification of assumptions, use of critical and logical thinking, and considerations of alternative explanations (NRC, 1996, p. 23).” Inquiry-based curriculum and instruction are structured so that study and learning are driven by students’ desires to answer self-generated questions (AAAS, 2000).

Problem-based learning (PBL) - A sequence of instructions which is 1) initiated by the presentation of an ill-structured problem, 2) guided learning issues associated with the problem and identified by the students, and 3) geared toward successful resolution of the problem. Students take on the role of problem solver and teachers act as facilitators of learning, guiding discussions, commenting on students’ reasoning, and steering students toward discovery and learning (VanTassel-Baska, Bailey, Gallagher, and Fettig, 1993).

Significance of Study

With the publication of such major documents as *Science for All Americans* (AAAS, 1989), *Benchmarks for Science Literacy* (AAAS, 1993), *National Science Education Standards* (NRC, 1996), and the *Third International Mathematics and Science Study* (National Center for Education Statistics, 1996), educators have become more aware of students’ inadequacies in science literacy as well as educational recommendations for instruction and content in science that should

foster increased student understanding of the subject. The next step in assessing the impact of these reports is to verify that instructional recommendations are being carried out in science educational settings. This report attempts to verify to what degree instructional strategy recommendations in science education are being implemented in specialized secondary schools for the gifted.

Likewise, the report *Nation Excellence* (Office of Educational Research and Improvement, 1993) made similar instructional recommendations for gifted learners. The field of science brings students, the discipline of science and social aspects of society together; an ideal combination for gifted students. A teacher's attitudes toward science can be either positive or negative in developing science-minded individuals. The role of the science educator in developing gifted, science-minded students who may eventually become scientists is a critical component in all fields of science and the nation as a whole. Therefore, if the nation's brightest individuals do not place a positive value on the understanding and learning of science, a long-term commitment to science and science understanding may be lost. This study provides documentation as to the use of appropriate and advanced instructional strategies for gifted students in the science classroom.

The development and field-testing of a classroom observation form that assesses both science reform initiatives and gifted education best practices was an

integral component of the research. Likewise, the form contributes to the field of gifted education, as well as science education. It could become a useful tool in assessing the implementation of reform initiatives in all science classrooms.

Ethical Safeguards and Considerations

The researcher made every effort to ensure participants' privacy and to provide the requested resulting information to participants. The College of William and Mary's School of Education's Human Subjects Committee reviewed and approved the procedures of the study prior to its initiation. In addition, the following measures were undertaken by the researcher to safeguard the participants:

1. An explanation of the study was provided to AYGS directors and teacher participants.
2. Assurance of confidentiality was stressed to the participants.
3. Each AYGS director and teacher participant was required to sign a consent form.
4. Student classroom surveys did NOT contain student names or any identifier of the student.
5. Any identification of individuals or school will not appear in the final report.

6. Each participating school director, teacher, and student was given the opportunity to obtain the results of the study.

Every effort on the researcher's part was taken to prevent any individual analysis or to compromise the identity of a particular individual. Individuals were given the researcher's phone number and email address to contact to request the results of the findings. Upon conclusion of the study and dissertation defense, any individuals making a request for findings will be sent the results of the study.

CHAPTER 2

REVIEW OF LITERATURE

Introduction

From the space race with Russia in the 1950's to *A Nation at Risk* (National Commission on Excellence in Education, 1983) to the *National Science Education Standards* (NRC, 1996), Americans have been adopting educational reforms specifically aimed at raising the level of science understanding and achievement in students and targeting the way science is taught in schools. Each recommendation recognizes the importance of teachers to the success of these reforms. Reforms call for a change from a teacher-centered approach to a student-centered approach of instruction (NRC, 1996; Rutherford & Ahlgren, 1990; Yager, 1996). Similar recommendations have come to light in the field of gifted education. Recommendations have been made regarding curriculum and instructional practices that should be implemented to support the educational needs of gifted students. Teachers should adjust instructional practices to differentiate for gifted students. Again, the importance of the teacher as key in providing curricular reforms and instructional practices for gifted did not go unnoticed (VanTassel-Baska, 1992; VanTassel-Baska, 1995; VanTassel-Baska, Bass, Ries, Poland, Avery, 1998; Gallagher, Stepien, & Rosenthal, 1992).

This review of literature will examine reform issues and subsequent changes that occurred in both science education and gifted education. One strand will examine science reform issues and recommended changes in science education. A second strand will explore issues and studies surrounding science curriculum and instructional effectiveness. A third strand will examine curriculum and instructional practices for gifted students. The final strand will review studies of effective curriculum and instructional practices in science classrooms for the gifted.

Science Education Reform Issues

The Education Summit of 1990 between President Bush and 50 governors from across the United States set forth a national goal to have science students lead the world in science achievement by the end of the decade. While leading the way in science achievement was a major focus of the Summit, the goal of science literacy for all students was just as important. In general, science reform initiatives have produced science content standards, professional guidelines, curriculum guidelines, and instructional recommendations toward the goal of science literacy for all students. Professional teaching certification in science has restructured practices in support of these reform initiatives. The science community and science educators have worked together to develop foundations and support mechanisms

that strive to implement the recommendations to accomplish the Summit goals.

What are these recommendations and standards that will structure science teaching and learning for science literacy?

With the development of *Science for All Americans* (AAAS, 1989) as part of Project 2061, the science education community had a 'road map' of directions for achieving science literacy for US citizens. *Science for All Americans* addressed the question of what understandings and habits of mind were essential for all citizens. In addition to providing recommendations in science content, the document provided insights into individuals, organizations, and educational institutions that could help transform science education. More specifically, *Science for All Americans* recommended changes to curriculum models, instructional materials, teacher and administrator qualifications, collaborations between scientific and educational organizations, and science educational research agendas. *Science for All Americans* took a holistic approach to its recommendations for changing the system of science education (AAAS, 1989).

Following *Science for All Americans*, the AAAS, in a collaborative effort with several science and educational organizations, produced *Benchmarks for Science Literacy* (AAAS, 1993). The *Benchmarks* provided a sequence of specific science learning goals to be achieved by students reaching a certain grade level. Dealing with

science content as well as scientific process skills, the *Benchmarks* were structured to allow for flexibility in science curriculum and instruction across grades K-12.

Building upon the *Benchmarks*, the National Research Council produced the *National Science Education Standards (NSES)* (NRC, 1996). Throughout, the *Standards* view science as a process, with inquiry as the critical focus to science learning. Various standards are presented in the text, providing criteria for judging science literacy. The *NSES* documents academic and professional standards for science teaching, professional development, and the assessment of science literacy, science education programs, and policies and practices in science education systems. For students, this means that the *NSES* provides content criteria for assessing the content, concepts, and process of learning and doing science. For administrators and educators, this means that the *Standards* provide criteria for developing, implementing, and evaluating science education programs. All of these *Standards* are focused toward the preparation of a scientifically literate society.

Both the American Association for the Advancement of Science and the National Research Council identified similar science content and performance standards through which they felt the US could achieve science literacy for all its citizens, eventually propelling it into an international leader in science education. These similar standards reflect science content knowledge, competency, and process

skills for students in K-12. Possibly the strongest thread that weaves these two organizational recommendations together is inquiry-based instruction, a central strategy for teaching science. In keeping with inquiry-based instruction is the students' acquisition of intellectual attitudes and values associated with inquiry-based learning in science. Emphasis is placed on understanding central ideas and concepts rather than rote memorization of facts and vocabulary. Similarly, professional development systems are encouraged to embrace these recommendations and restructure teacher education programs to facilitate these recommendations in the learning and teaching of science.

The establishment of the *Adolescence and Young Adult Science Standards for Teachers* (National Board of Professional Teaching Standards, 1997) by the National Board of Professional Teaching Standards recognized the recommendations set forth by the *NSES* (NRC, 1996) and the *Benchmarks* (AAAS, 1993). Through its teacher certification requirements, the NBPTS recognizes the importance of inquiry in science learning and teaching, conceptual understanding of science concepts, social contexts as relevant to science understanding, student engagement in learning science, and the role of the science teacher as a facilitator of knowledge acquisition. In order to achieve these teaching standards, NBPTS stresses the value of teacher

professional development opportunities that include science content acquisition, collegiality and leadership, and reflection.

Numerous state and local science standards have been developed that utilize the *Benchmarks* and the *NSES* as their foundation. However, since the establishment of all these forms of standards for guidance in the process of learning and teaching science, the real challenge has been to implement these reform efforts (Hobson, 2001; Llewellyn, 2001). Have science teachers' instructional strategies changed to accommodate these recommendations and, if so, are they effective strategies in accomplishing science literacy among students?

Science Curriculum and Instructional Effectiveness

Like many of the science reform efforts undertaken in the 1950's and 1970's, current science reform recommendations see science curriculum and teacher instructional practices as keys to implementation. Past recommendations advocate more hands-on, student-centered approaches to science instruction. However, past efforts have produced minimal impact in these areas; teachers and curriculum have fundamentally gone unaffected by past reform efforts (American Association for the Advancement of Science, 1998). The current reform recommendations include more of an orientation in student learning towards mental engagement in higher-level

thinking skills and an increase in teacher instructional methods and curriculum that incorporates these opportunities for students.

Several studies have examined the role of teachers' instructional practices in keeping with national reform recommendations. Wenglinsky (2000) pointed out that while teacher inputs, professional development and classroom practices all influence student achievement, the greatest role is played by classroom practices. One such practice, hands-on science, an activity that allows students to see and verify science phenomena or some aspect of it, has been an issue in science reform for several decades. Teachers utilize hands-on strategies to actively engage students in the learning process. Hands-on instruction provides an excellent avenue for visual, active learning for elementary and middle school students. In high school science classes, teachers need to extend students' learning from a hands-on demonstration approach to a more discovery of concepts and ideas approach (Ruby, 2001).

Evidence supports the impact science reform instructional recommendations have on students' science achievement. One study by Von Secker and Lissitz (1999) found that instructional practices associated with the national science standards, such as laboratory inquiry, critical thinking, and reduced teacher-centered instruction, were associated with higher student achievement overall. Wenglinsky (2000) recognized similar approaches as impacting students' achievement in science

at the middle and high school levels; more specifically, approaches utilizing higher-order thinking skills and metacognitive strategies. In a meta-analysis of research involving the use of problem-solving strategies in the classroom, findings suggested that reflection by the student, feedback from the teacher, and the use of guidelines and criteria for evaluating student performance were classroom practices that promoted problem-solving skills (Taconis, Ferguson-Hessler, & Broekkamp, 2001). In keeping with these findings, teachers' use of questioning strategies and the students' ability to ask relevant questions were found to be classroom practices that encouraged active inquiry learning and student achievement (Goodman and Berntson, 2000; Cuccio-Schirripa and Steiner, 2000). In each of these studies, classroom practices impacted student acquisition of important skills and science knowledge.

As stated earlier, the NRC (1996) places importance on students' investigating and analyzing science from social perspectives as one of the reform issues in science education. Tobin and Tippin (1993) elaborated on the idea that constructivism is a belief system about teaching and learning, as opposed to a method of teaching (Fosnot, 1996). Contextual or social constructivism aligns a model of learning and the student together through the mediation of a teacher, with learning grounded in a social context. The student constructs knowledge upon an existing knowledge base through a mediated interaction between teacher and student and student and

student. Here, the varying meanings of 'social context' become evident. Social context refers to the interaction that occurs between teachers and students, as well as among students themselves. In social interaction, the learning is centered in a social - cultural context. It is in this broad social-cultural context, that science knowledge has meaning and relevance for the learner (Cobern, 1993). This translates into teachers providing opportunities for students to discuss and reflect on science content in light of a social context. Rop (1999) comments that the social aspects of learning, both from making connections to the outside world and amongst students in the classroom, are key to students' perceptions of a successful learning environment.

Research from the field of science education provides insights into the effects that positive attitudes have on science achievement. Many studies have found that a positive relationship exists between students' attitudes toward science and their achievement in science (Harty, Beall, & Scharmann, 1985; Barrington & Hendricks, 1988; Benbow & Arjmand, 1990; Napier & Riley, 1985). However, other studies have shown that while students possess positive attitudes toward science in the elementary years, these positive attitudes diminish as students progressed to higher grades (Yager & Yager, 1985; Yager & Penich, 1986; Brunkhorst & Yager, 1986; Walberg & Ahlgren, 1973; Shymansky & Kyle, 1988). As a result, educators have suggested that a new curricular and instructional approach to science education

is in order to positively affect students' attitudes toward science. A recent meta-analysis by Shymansky, Kyle, and Alport (2003) found that students experiencing reform-oriented science curricula and instruction performed better in general achievement, analytical and process skills, and had a more positive attitude toward science.

Similarly, studies of college science students' perceptions of science teaching suggest that many national science reform instructional strategies provide positive learning environments and support student achievement. Teachers in these studies used hands-on laboratory approaches, critical thinking skills, and a variety of grouping strategies that impacted students' perception of the learning environment (Deeds, Wood, Callen, & Allen, 1999; Kardash & Wallace, 2001; Leonard, 2000). College students viewed critical thinking opportunities and hands-on laboratory approaches to instruction, along with the use of computers, as crucial to the understanding of math and science (Deeds, et. al., 1999).

For teachers adopting reform-initiated curriculum for science education, the transition from the traditional teacher-centered approach of *giving* information to an approach that helps the student to search for and understand information is challenging. How administrators will assess their instructional approaches is a major concern for teachers (Boyce, VanTassel-Baska, Burruss, Sher, & Johnson, 1996). If

teachers are expected to utilize more student-centered instruction, their role should be evaluated with respect to those instructional practices and not just the traditional teacher-centered approaches (Lopez and Tuomi, 1995; Adams and Krockover, 1999). This is not to say that traditional teacher-centered approaches, such as direct instruction, are not warranted in science curriculum, but that the frequency and scope of such instructional approaches are diminished.

Of critical importance to the implementation of recommended classroom practices are teachers' level of experience with instructional methodology, their intentions for instruction, and their perceptions of the students (Lederman, 1999). Several studies have examined the implementation of science reform instructional strategies by science teachers related to staff development. Findings indicate the need for intensive and continued staff development on instructional practices such as inquiry and constructivist approaches (van Driel, Beijaard, and Verloop, 2001; Supovitz and Turner, 2000; Davis, 2003). Findings from Windschitl's (2002) review of studies on constructivist teaching suggest that one of the most important components of constructivist strategy implementation is teacher pedagogy; teachers should be able to relate strategies to learning theory as well as the benefits and consequences for their student population. Other studies suggest the need for evaluation measures that capture the implementation of science reform indicators in

the classroom and involve teachers in the utilization of those tools (Keys and Bryan, 2001; Adams and Krockover, 1999). While many of these studies focus on a particular aspect of staff development, all of the studies call for more research on the use of science reform instructional strategies and the impact staff development has on implementation.

Gifted Education Curriculum and Instructional Effectiveness

A Nation at Risk (National Commission on Excellence in Education, 1983) focused the American educational system on reform issues for educating students to be competitive in the world work force. However, it wasn't until the publication of *National Excellence* (OERI, 1993) that educators began to examine the need for differentiated curriculum for gifted learners. *National Excellence* (OERI, 1993) called for challenging curriculum and advanced learning opportunities for the nation's top performing students, suggesting that most top students were spending time "working well below their capabilities" (OERI, 1993, p.5). The report called for challenging curriculum standards, both in the selection and development of curriculum, and for high-level learning opportunities for gifted students. These two recommendations, of the five suggested by the report, are the most critical in their impact on curriculum and instructional practices for the gifted.

Suggestions made by *National Excellence* (OERI, 1993) call for the use of advanced-level curriculum that allows students to move at a pace consistent with their abilities. In keeping with the academic level is a need for the curriculum to provide in-depth work with an interdisciplinary focus. Conceptual understanding and higher-order thinking skills become an integral part to achieving an interdisciplinary focus within the curriculum. In order for the curriculum to be effective, teachers must provide high-level learning opportunities for students to experience the curriculum, emphasizing discussion, inquiry, acceleration, and enrichment.

The *Integrated Curriculum Model* (ICM) for Gifted Learners (VanTassel-Baska, 1995) provides a model through which the curricular suggestions made in *National Excellence* (OERI, 1993) can be achieved. The ICM calls for three major areas to be addressed within a curricular framework: an advanced-level content dimension; a process-product dimension; conceptual understanding dimension. The advanced-level content dimension allows for a diagnostic prescriptive (D-P) instructional approach to moving students through the advanced level curriculum. With the D-P approach, students can move through at an appropriate pace, compacting and accelerating the curriculum based on their abilities. The process-product dimension allows for students to enhance their investigative skills, problem-solve, and collaborate with both teacher and peers as they explore a topic. The

collaboration within this dimension facilitates a social learning component and allows for discussion and critical thinking opportunities. Finally, the conceptual understanding dimension raises the level of learning by providing a framework through which students can connect various topics and information in an interdisciplinary fashion (VanTassel-Baska, 1986; 1994; 1995).

While recommendations call for changes in curriculum, there must also be changes in the instructional process. Teachers must provide classroom and out of classroom experiences that foster some of the curricular issues discussed previously. For many teachers, this will mean a change to their instructional approach, from one of lecture and grades to one of emphasizing high-level thinking skills and discussion. Teacher training in gifted education is a necessary component to effectively implement changes in curriculum and instruction of gifted students (Reis & Westberg, (1994); Hansen & Feldhusen, 1994). Reis and Westberg (1994) found that teachers who received the most intensive staff development were more likely to implement strategies in the classroom and to continue use of the strategies in the future. In a recent study by VanTassel-Baska and Avery (2002), instructional strategies of teachers in a variety of classrooms for the gifted were observed for behaviors that correspond to national gifted recommended practices. Findings indicated that although teachers of the gifted at various grade levels and in various

content domains had received staff development on instructional strategies, implementation of strategies was distributed unevenly and, in general, was utilized less frequently than expected.

On a school-wide level, implementing gifted education reform best practices requires a school-wide effort. The incorporation of gifted recommendations throughout a school or program requires a successful restructuring based on recommendations from a review of current curriculum, documents, classroom observations of instructional practices, and interviews and focus groups with a variety of constituent groups (VanTassel-Baska, Leonhard, Glenn, Poland, Brown, and Johnson, 1999). In summary, the implementation of best practice recommendations requires staff development, administrative support, and classroom observation and evaluation.

Effective Science Curriculum and Instructional Practices for the Gifted

While this literature review deals with research and reforms from science education and gifted education separately, a few studies show a combined look at science reform issues as they are implemented for gifted students. Elements of gifted education recommendations and national science reform issues are similar in their approach to science instruction. Both approaches recommend practices that

allow students to discover and explore concepts and information. An integral part of this exploration is a curriculum that is inquiry oriented in its approach to learning. In combination with inquiry is the opportunity for students to explore issues more in-depth and at a higher academic level of understanding imploring the use of higher level thinking skills. Recommendations call for an affective element in curriculum, where students learn values and social issues associated with concepts and content. Finally, the production of a product by students is a performance opportunity to demonstrate what they have learned; this may be an experiment in some science courses (AAAS, 1993; NRC, 1996; National Association for Gifted Children, 1998; OERI, 1993; VanTassel-Baska, 1995; Johnson, Boyce, & VanTassel-Baska, 1995). There is strong congruency among the recommendations for gifted best practices and those for science education reform.

One example of a curricular and instructional framework that merits consideration for gifted learners in a science course is problem-based learning (PBL). A PBL model, such as the W & M unit *Acid, Acid Everywhere* (Center for Gifted Education, 1997a), aligns elements of appropriately differentiated curriculum and instruction for gifted learners in the integration of advanced levels of content, a process-product dimension, and a concept orientation (VanTassel-Baska, 1995). The advanced content dimension offers challenging learning opportunities for high ability

learners, but also allows for acceleration through and/or in depth exploration of content in keeping with national science standards. Teachers have the flexibility to pace instruction through the lessons as they deem appropriate for their student population. Lessons provide extension activities for students who master the content of the lesson and wish to explore the content in more depth. Student activities and the creation of products throughout the unit allow for creative expression of thought as well as contributing to students' understanding of content and its relationship to the problem. With the concept orientation of the PBL unit toward 'systems', the unit fosters interdisciplinary connections outside of science and the application of higher-order thinking and reasoning skills, all of which align with gifted education and national standards best practices. Throughout the unit, students address the problem from various perspectives. Additional elements found throughout the unit that support effective teaching for gifted learners can be found in the metacognitive questions, scientific habits of mind, technology-relevant usage when applicable, and critical thinking opportunities (Center for Gifted Education, 1997b; VanTassel-Baska, 1992).

The PBL model addresses some of the affective needs of the gifted learner also. Opportunities for collaboration and group activities exist as students work in teams for problem solving and researching information. Students have an opportunity

to share their information with their peers through the product dimension of the model (Center for Gifted Education, 1997b; VanTassel-Baska, 1992). These collaborative opportunities are reflective of gifted recommendations for flexible grouping patterns in the classroom.

Teachers play an instrumental role in the constant evaluation of students' progress, both individually and as a group, towards stated objectives and in monitoring levels of challenge and complexity offered to the students by the problem. Teachers are interactive in the learning process, scaffolding knowledge and supporting students in their own learning and conceptual understanding (Howe, 1996; Boyce, et. al., 1997). This greater degree of teacher involvement is imperative to successful implementation of PBL in the secondary and elementary settings (Center for Gifted Education, 1997b). With the teacher in the role as a facilitator of learning, the stage is set for the teacher to provide effective science teaching for gifted learners (West, 1992).

Research in the K-12 science community as to the effectiveness of a PBL curriculum is sorely lacking. Some research has attempted to examine particular aspects of PBL. One study by Gallagher, Stepien, & Rosenthal (1992) found that problem-based learning helped students to develop their problem-solving skills. Two studies of content acquisition in the PBL classroom reported that students' content

acquisition was often greater in PBL courses due to the interdisciplinary nature of the PBL problem (Stepien, Gallagher, & Workman, 1993; Gallagher & Stepien, 1996). Another study, by the Center for Gifted Education at The College of William and Mary, found significant growth gains of students' process skills in experimental design after utilization of the problem-based unit *Acid, Acid Everywhere* (VanTassel-Baska, Bass, Ries, Poland, & Avery, 1998). Each of these studies found that PBL positively affected the variable being studied. These variables also address recommendations from both gifted best practices as well as science reform issues.

A curriculum review by Johnson, Boyce, and VanTassel-Baska (1996) examined various science models for aspects of gifted education curriculum and the national science education reform issues. Classroom textbooks were found to be inadequate in both the areas of gifted curriculum and science curriculum reform. However, some science models did contain the components of both good gifted curriculum and good science curriculum. Studies on the implementation of these models in light of the national science standards are lacking.

Another study conducted prior to the national science education standards being released examined teachers' and gifted students' use of technology (computers) in an inquiry-learning classroom (Peck & Hughes, 1994). Findings indicated that both teachers and students benefited from an inquiry-learning

environment that was rich in technology. Benefits fell into several categories: the use of technology as a thinking tool; more technology integrated into the curriculum; positive impacts on students thinking; changes to the traditional roles of teacher and student; more collaboration; and confident attitudes in the use of technology. Overall suggestions from this study, although occurring prior to national standards, reveal the importance of technology and inquiry as relevant to gifted students education.

Two recent studies dealing with the impact of science enrichment programs on gifted students' attitudes toward science were promising. In one study using multiple measures to assess the impact of gifted high school students' attitudes toward science (Stake & Mares, 2001), the overall impact of a science program that focused on scientific research methods was positive on gifted students' attitudes toward science, especially for girls. The program contained elements of both gifted and science reform recommendations. Similarly, positive changes in gifted students' attitudes toward science were experienced in a field-based research program that adhered to both gifted and science curriculum recommendations (Schenkel, 2002). This program was focused on students from 7th through 10th grade. It is important to note that these programs did not occur in the typical classroom setting and were strongly focused toward research.

In another science program for the gifted, students participated in a fast-paced, 3-week summer program equivalent to a yearlong high school biology course. Six years of student data were analyzed over the course of the study. Students were extremely successful in the final standardized test and continued to progress during the regular school year in succeeding science courses. This study concluded that fast-paced science curriculum was appropriate for gifted learners (Lynch, 1992).

The following table, Table 1 Literature Review Matrix, provides an overview of the research literature from the four strands of work reviewed for this study: science education reform issues, science curriculum and instructional effectiveness, gifted education curriculum and instructional effectiveness, and effective science curriculum and instruction for the gifted.

Table 1
Literature Review Matrix

STRANDS	STUDIES	MAJOR FOCUS	GENERAL FINDINGS
Science Education Reform Issues	Science for All Americans (AAAS, 1989)	Road map to science reform	Advocated science literacy for all Americans; provided a 'road map' to the changes needed in the science education system
	Benchmarks for Science Literacy (AAAS, 1993)	Specific learning goals	Specific learning goals for k-12 students; inquiry orientation to learning and teaching science

STRANDS	STUDIES	MAJOR FOCUS	GENERAL FINDINGS
Science Curriculum & Instructional Effectiveness	National Science Education Standards (NRC, 1996)	Science content and professional standards	Specific standards for k-12 students; standards for science teachers & administrators; program standards; professional development standards
	Adolescence & Young Adult Science Standards for Teachers (NBPTS, 1997)	National science teacher certification standards	Provided criteria for assessing science teachers on levels of professional development and effective instruction in keeping with <i>Benchmarks</i> and <i>NSES</i>
	Ruby (2001)	Hands-on science and achievement	A positive relationship exists between hands-on science and student achievement on multiple choice tests and performance-based assessments.
	Harty, Beall, & Scharmann (1985)	Attitudes toward science & achievement	Positive correlations were found between achievement in science and students' attitudes, interest, curiosity, and aptitude in science.
	Barrington & Hendricks (1988)	Attitudes toward science & achievement	For intellectually gifted students, changes in attitudes and achievement in science are negatively correlated as students progress through school.
	Benbow & Arjmand (1988)	Variables predictive of science achievement	Variables predictive of science achievement in mathematically talented students included experiences/curriculum in science and students' attitudes toward science.
	Napier & Riley (1985)	Attitudes toward science	As students move through the educational system, their attitudes regarding science become increasingly negative.
	Yager & Yager (1985)	Students' perceptions of science	Students' perceptions of science programs become more negative as they move through the educational system.
	Yager & Penich (1986)	Students' perceptions of science	Students' positive perceptions of science and its usefulness decline as they get older
	Brunkhorst & Yager (1986)	Students' science understanding	As students move through the education system, their understanding of science diminishes and their attitudes regarding science become negative.
	Adams & Krockover (1999)	Constructivist teaching styles	Observation rubrics focused on constructivist behaviors as tools for novice teachers' evaluations can help change instructional practices.
	Davis (2003)	Teacher instructional practices	Certain staff development opportunities facilitate or hinder teachers implementation of national science reform initiatives.
	Keys & Bryan (2001)	Teacher instructional practices	A review of literature confirms the need for more research into science curriculum and instruction that facilitates inquiry-based learning.

STRANDS	STUDIES	MAJOR FOCUS	GENERAL FINDINGS
	Supovitz & Turner (2000)	Teacher instructional practices	The study suggests that the quantity of staff development a teacher receives impacts the implementation of inquiry-based practices.
	Van Driel, Beijaard, & Verloop (2001)	Teacher instructional practices	Long-term professional development is needed to achieve lasting changes in teachers' practical knowledge and instructional practices
	Rop (1999)	Students' science understanding	College-bound students in an advance chemistry course reveal that a deeper understanding of the subject is as important as a good grade.
	Taconis, Ferguson-Hessler, & Broekkamp (2001)	Meta-analysis on problem-solving	Meta-analysis on students' use of problem-solving skills – provision of guidelines for reflection and feedback had the most impact.
	Zachos, Hick, Doane, & Sargent (2000)	Students' science understanding	Students with certain competency skills were better at conducting science inquiry and were more successful in concept attainment.
	Windschitl (2002)	Teacher instructional practices	A review of studies that examined issues of teacher experiences, training and development, and classroom/school culture & how they impact the use of constructivist strategies in teaching.
	Wenglinsky (2000)	Teacher instructional practices	An examination of NAEP data supports the notion that higher order thinking skills and metacognition leads to improved student performance in science and mathematics.
	Cuccio-Schirripa & Steiner (2000)	Students' science understanding	Students' ability to question their understandings of science lead to greater comprehension of the science topic.
	Deeds, Wood, Callen, and Allen (1999)	Student attitudes about science learning	Various areas of students' attitudes toward science were explored – the area of pedagogy provided insights into how students view labs, critical thinking skills, group work, and science learning.
	Goodman & Berntson (2000)	Teacher instructional practices	Authors' reflection, with other research, on how the use of questioning strategies by teachers impacts the 'inquiry' atmosphere of the classroom
	Kardash & Wallace (2001)	Teacher instructional practices	Undergraduate students provide insights into teachers' instructional practices and how those practices effect their learning of science.
	Leonard (2000)	Teacher instructional practices	Undergraduate science students were supportive of a more constructivist approach to learning science.
	Shymansky, Kyle, & Alport (2003)	Students' science understanding	Meta-analysis of the use of science curricula that embraced new reform issues – greater science understanding was found for students who experience the new curriculum.
	Walberg & Ahlgren (1973)	Attitudes toward science & achievement	A positive relationship exists between students' attitudes toward science and their achievement in science.

STRANDS	STUDIES	MAJOR FOCUS	GENERAL FINDINGS
	Shymansky & Kyle (1988)	Attitudes toward science & achievement	A positive relationship exists between students' attitudes toward science and their achievement in science.
	Von Secker & Lisztz (1999)	Instructional practices in science and achievement	Instructional practices (specifically, laboratory inquiry, critical thinking, and reduced teacher-centered instruction), when associated with the national science standards, result in higher student achievement overall
	Lederman (1999)	Teachers' understanding of science	Of critical importance to the implementation of classroom practices recommended by the national standards are teachers' level of experience with instructional methodology, their intentions for instruction, and their perceptions of students.
Gifted Education Curriculum & Instructional Effectiveness	National Excellence (OERI, 1993)	Gifted Education	Called for reform of the educational system in support of the needs of gifted learners.
	Hansen & Feldhusen (1994)	Teacher training	Teachers trained in gifted education had greater teaching skills and developed more positive classroom climate than untrained teachers.
	Reis & Westberg (1994)	Teacher training	The more training teachers received in curriculum compacting the greater degree to which they incorporated the instructional skills into their classroom practices.
	VanTassel-Baska (1995)	Gifted curriculum	A model for curriculum for gifted learners should encompass an advanced content component, a concept orientation, and a process/product dimension.
	VanTassel-Baska & Avery (2002)	Instructional reform	Teachers of the gifted employ fewer higher level strategies than anticipated; critical thinking & problem-solving strategies were underutilized.
	VanTassel-Baska, et. al (1999)	Curriculum review	Curriculum review, documents, interviews, focus groups, and classroom observations were used to develop recommendations for incorporating gifted education reform in a magnet secondary school.
Effective Science Curriculum & Instruction for the Gifted	Gallagher, Stepien, & Rosenthal (1992)	PBL and problem-solving	After experiencing a problem-based learning unit, students demonstrated increased abilities in problem solving skills.
	Stepien, Gallagher, & Workman (1993)	PBL and content acquisition	Students in a problem-based learning situation acquired as much if not more content than students in a traditional classroom setting in the humanities.
	VanTassel-Baska, et. al (1998)	PBL and experimental design	Students experiencing a PBL science curriculum demonstrated significant growth gains in their understanding of experimental design elements.
	Johnson, Boyce, & VanTassel-Baska (1996)	Science curriculum review	Science textbooks did not meet the requirements for either gifted or science reform issues; some modular science programs received high ratings

STRANDS	STUDIES	MAJOR FOCUS	GENERAL FINDINGS
	Lynch (1992)	Science programs for the gifted	Students in a fast-paced summer biology course did exceptionally well, suggesting gifted students could start science courses earlier than is currently practiced in the U.S.
	Peck & Hughes (1994)	Technology with inquiry learning for the gifted	Inquiry learning in a technology-rich environment in gifted classes impacts student thinking; technology should be used as a thinking tool and integrated into the curriculum.
	Stake & Mares (2001)	Science programs and gifted students' attitudes	Multiple measures of gifted students', especially girls, attitudes toward science were positively affected by a science enrichment program focused on research.
	Schenkel (2002)	Science programs and gifted students' attitudes	Gifted students attending a field-based research program experienced positive gains in their attitudes towards science.

Conclusion

In summary, the specific strands under review in this research provide a collective focus for understanding how science reform initiatives and best practices for gifted students link together. In general, many of the science reform initiatives, such as inquiry based learning, student-centered instruction, critical thinking, and concept development, complement the recommended practices in gifted education. Research from both fields supports the application of these recommendations for gifted learners taking a science course. Positive increases in students' attitudes, content acquisition, and overall achievement have occurred as a result of their

implementation. However, few studies specifically attempt to examine the overall frequency of use of these recommendations in a science course for gifted high school students.

"Specialized schools for the gifted serve several purposes, including providing models for high educational standards in a state and augmenting economic development (VanTassel-Baska, et.al., 1999, p. 173)." Are Virginia's Academic Year Governor's Schools a role model for implementation of science reform initiatives and gifted education best practices? "Reformers should develop and refine models of science teaching that align with the goals of *Benchmarks* and the *Science Standards*, use them as the basis for evaluation systems, and tie staff development to evaluation to produce a system that builds science teaching competency toward standards-based goals (AAAS, 1998, p. 49)." This study examined the extent to which science teachers in Academic Year Governor's Schools are adhering to the national standards for suggested science instruction and are providing an appropriate learning environment for gifted learners, and in doing so, are creating an environment that meets students' expectations for science instruction at a specialized secondary school for gifted students.

CHAPTER 3

METHODOLOGY

Introduction

The Virginia Department of Education (VDOE), and the school divisions within their service region govern Academic Year Governor's Schools in Virginia. Yet, actual implementation of instructional strategies and course curriculum are developed and monitored by the schools themselves. Periodic (once every 3 or 4 years) reviews by the Virginia Department of Education provide suggestions regarding a variety of instructional and curricular matters.

Most of the critique of Governor's School programs by the VDOE relies on a modified version of the National Association for Gifted Children's Standards for Gifted Programs (NAGC, 1998). While many of the modifications under the instructional component of that modified document link to national science reform recommendations, schools must rely on teacher evaluation instruments to provide feedback regarding implementation of science reform recommendations. Since teacher evaluation instruments may or may not serve to evaluate the implementation of science reform recommendations or the use of instructional strategies for gifted learners, this study examines the extent to which national science and gifted

standards and instructional recommendations are being implemented in these specialized schools for the gifted.

Sample

A total of 15 Governor's Schools are located throughout the Commonwealth of Virginia. For this study, 13 Governor's Schools participated in this research.

Therefore the sample size was almost the same as the population of AYGS in the state. Regarding the two schools who did not participate in the study, one does not teach science and the other is under new directorship and did not consent. Thirteen directors from the participating schools returned completed surveys, representing 100% participation.

Two of the Governor's Schools are located in rural areas in the southwestern portion of the state. Four of the schools are located in large cities and are considered urban in the location. Finally, the remaining seven schools are located in rural sites in the central and eastern portions of the state. Geographically, seven schools are located in or close to the mountains; two schools are located in the Piedmont Region; four schools have coastal locations.

Participating instructors from each school were high school teachers of advanced science courses that target mainly 11th and 12th grade students. Some

schools hired teachers as full-time or part-time (adjunct) instructors, while other schools utilized personnel from supporting community colleges. The instructors that participated in this study had a variety of backgrounds and experiences in both working with gifted students and teaching science. An exact delineation of their backgrounds will be discussed in Chapter 4 of this study. For the instructor's survey, the sample size of high school teachers was 54 out of a possible 61 teachers of advanced science courses for 11th and 12th graders in the 13 participating schools, representing 89% participation rate. A total of 1190 student surveys were submitted to the study; these surveys were from students of the 54 participating teachers. It is uncertain as to how many students chose not to participate in the study. Advanced science classes and teachers were targeted for this study to guarantee that the curriculum design and instruction was not driven by the Virginia Standards of Learning requirements; a state regulated curriculum guide that may impact the teacher instructional practices.

Classroom observational data were collected from four Governor's schools. The initial proposal included classroom observations from six Governor's Schools. These six schools were selected sites for observational data in order for the researcher feasibly to be able to reach the sites to conduct the study, a limitation in the research. However, due to weather conditions, two schools were not in session

for much of the researcher's time available for classroom observations. In addition, partly due to time constraints dictated by the snowfall and school closings, some follow-up classroom observations that were to be conducted by school staff were not conducted. Initially, the six schools were selected based on geographic location, program structure, and urban/rural classification. However, the four schools that were observed onsite still reflected statewide diversity in respect to demographics. Regarding demographics, two schools were urban in location, two schools were rural in location, one school was a full-day program, and three schools were shared-time programs. Teachers selected at the four Governor's Schools were, for the most part, the population of science teachers available within those schools. A total of 19 teachers participated in a total of 39 classroom observations in the study.

Research Questions

The following questions were examined as components of this study:

1. How do science teachers' instructional practices vary by the following demographics: urban vs. rural location; fulltime vs. shared-time programs; teacher content area mastery vs. pedagogical certification; science ability vs. general academic ability as entry criteria for students?

2. What are the specific science instructional reform initiatives being employed by science teachers in specialized schools for the gifted?
3. What are the specific gifted education instructional strategies being employed by AYGS science teachers?
4. With what frequency do teachers in specialized secondary schools report using science reform instructional initiatives; with what frequency are instructional strategies for the gifted reportedly employed by these teachers?
5. What relationship exists between students', teachers', and outside observers' perceptions of science instruction in advanced science courses at AYGS?

Procedures

Initially, the researcher contacted each participating Governor's School director (Appendix A) to inform them that they would be receiving materials to assist in conducting the researcher's study and to schedule an on-site visit at the particular AYGS where teacher observations would be conducted. All the administrators were sent a letter that explained the study (Appendix B), participant consent forms (Appendix C), and two demographic surveys; one that was completed

by the director (Appendix D) and the other that was completed by the participating instructors at the school (Appendix E). These forms provided the demographic information on the AYGS, the director, and the instructors, as well as additional information regarding the instructors' perception of their implementation of reform initiatives in science and gifted education. Accompanying these forms were the student classroom survey (Appendix F) forms. Directions were sent with these forms, instructing the director to distribute and collect the forms from students of participating teachers. A letter to the students' parents and a parental consent form (Appendix G) was provided to the director should he/she feel consent forms were required to survey students. The director was instructed to group students' responses by course and by instructor. The survey ascertained students' perceptions of their teachers' use of instructional strategies at the school.

Of the AYGS participating in the survey study, only four schools had on-site investigations conducted over the length of the study. At these four schools, the directors determined a schedule for the researcher's classroom visitation. Therefore, visitations to the classroom were planned, and teachers knew of the researchers' intent to observe class that day and time. Subsequent follow-up observations by either the researcher or another director were unannounced observations. Classroom observations of science courses were conducted using the

Science and Gifted Education Classroom Observation Form (Appendix H). The observation form consists of two parts; the first page was the researcher's scripted observation of the classroom and lesson; the second page provided the researcher with a checklist of teacher behaviors and classroom indicators that require a checkmark to indicate their presence in the classroom. Each page of the observation form provided the researcher with insights into the utilization of reform initiatives in science and gifted education in science classrooms at AYGS. Each observation lasted approximately 30 minutes. The visitation schedules included classroom observations for each of the participating teachers and time in the schedule for the researcher to interview the participating teachers using Teacher Interview questions at the bottom of the first page of the observation form. These questions were used to clarify and verify the researcher's scripted observations of the observed lesson.

For the four schools slated for classroom observations, the researcher visited each school to do initial classroom observations of participating teachers. During the visit to two schools, the researcher trained the AYGS director or an appointed representative (referred to as the 'assistant researcher') on the use of the observational instrument. The training procedure consisted of the following steps: 1) the researcher explained all aspects of the observational form and procedure to the

assistant researcher; 2) the researcher and the assistant researcher observed at least three classrooms, individually completing a Science and Gifted Education Classroom Observational Form for each observation; 3) after the teacher interview, the observers compared scripting and the indication of observed behaviors; 4) a comparison of the researcher's form and the assistant researcher's form was made and differences were discussed; 5) if the assistant researcher did not feel comfortable with the form after three observations, the assistant was allowed to participate in the remaining observations.

Due to the unfortunate weather conditions and the loss of many school days to closings, the time available for observations was greatly diminished. Even when school was in session, teachers were conducting tests and hosting special events that restricted the observational time even further. In addition, some directors were faced with less time to conduct administrative duties, and therefore, opted not to make additional observations under the time constraints. At the conclusion of the observational period, the AYGS director forwarded all observation forms and any additional classroom materials from those observations to the researcher. The researcher sent reminder emails and placed phone calls if the observations forms and survey forms were not returned within a predetermined timeframe.

For each site, data were numbered to represent the school site (*e.g.*, S1, S2, S3 for site designation) as well as the returned surveys (*e.g.*, S1D, S2D, S3D for director's survey; S1I1, S1I2, S1I3 for instructor surveys). In addition, corresponding student classroom surveys and classroom observations had identification markers so they might be properly linked for the purpose of analysis (*e.g.*, S1I1O1, S1I1O2, S1I1O3 for classroom observation would link to S1I1S for student classroom survey). All data were entered into a database for the purpose of analysis.

Instrumentation

The researcher adapted the classroom observation form, the Science and Gifted Education Classroom Observation (SGECO) Form, from existing forms used at the College of William and Mary. The form is comprised of 28 items; 22 items are modified from the W&M External Observer Form developed by the Center for Gifted Education at the College of William and Mary (Avery, 1999), and 6 items were modifications of science classroom indicators taken from the Curriculum Reform Classroom Indicators in a *Guide To Teaching A Problem-Based Science Curriculum* (Center for Gifted Education College of William and Mary, 1997b). The W & M External Observation Instrument was found to have a content validity rating of .96

(Avery & VanTassel-Baska, under review) and a .63 inter-rater reliability (Avery, 1999). The sub-categories of the W & M External Observation instrument were found to have a .82 inter-rater reliability using Cohen's Kappa (Feng, 2001).

The first page of the SGEEO requires the observer to script his/her observations of the classroom instruction. The next page contains a 28-item behavior list on which the observer is to record a check mark for observed by marking the appropriate box beside each behavior, and leaving the box blank to indicate a non-observed behavior. The behaviors are comprised of two major components: gifted education initiatives and science reform initiatives. Indicators of gifted education and science reform can be sub-categorized into general teaching strategies (questions 1-8), problem-solving strategies (questions 9-14), critical thinking strategies (questions 15-19), metacognition (questions 20-22), and science reform indicators (questions 23-28).

Review of this instrument by three experts in both science and gifted education was conducted prior to its use in the study to establish the validity of the instrument. The researcher noted the experts' suggestions, but made only minor changes to the instrument's wording. Most suggestions offered by the experts highlighted their feelings that many students, and perhaps some teachers, may not understand the educational wording used in the instrument in the 28-item behavioral

list. While the researcher wanted to maintain the instrument in a form as close as possible to the W & M External Observer Form, the researcher did add a few examples as part of some of the behavioral list items.

The observation time lasted approximately 30 minutes. A composite score of observed behaviors was determined by summing the items checked on each observation form. In addition, once the observations were entered into a database, the behaviors were summed according to each of the 28-item behaviors, and overall according to the major categories (general teaching behaviors, problem solving, critical thinking, metacognition, and science reform indicators).

The researcher developed the director, instructor, and student classroom surveys for the purpose of this study. The instructor and student survey forms were piloted on a group of science teachers ($n=7$) and students ($n=35$) prior to the instrument's use. All science teachers in one school were given the instructor's survey form to complete and comment on regarding format, wording and ease of use. Similarly, two advanced-science classes of students were given the students' survey form to complete and comment on regarding format, wording, and ease of use. After reviewing the comments from science teachers and students, the researcher made modifications to the wording of demographic questions and layout of the instrument:

however, the 28-item science and gifted education behavioral list remained, for the most part, unchanged.

The director and instructor surveys included items such as levels of education attained, years in position and total years of involvement in education, and training in science and gifted education. In addition, each survey contained forced choice and open-ended questions dealing with school issues, such as program goals, staff development, and teacher evaluation. On the instructor's survey, an additional question replicated the behaviors found on the Science and Gifted Education Classroom Observation Form, but asked for responses in a six-level Likert scale format. Similarly, for the purpose of this study, the students' classroom survey form also contained the six-level Likert scale format of observed classroom behaviors, plus two additional questions. Both instructor and student survey forms asked participants to provide additional demographic data.

Data Analysis

Analysis of the data occurred at three levels. The first level of analysis was descriptive and examined Governor's Schools at the state level in totality.

Demographic data on each site and the directors was summarized into a table; this information was obtained from the director's surveys. Also at the state level, some

of the demographic information regarding instructors and students was summarized. These summations, not only provided an overall view of the schools and participants in the study, but served, in part, as answers for some of the research questions. Some comparisons were made between groups of schools, depending on various factors, such as location and program focus.

At the classroom level of analysis, the student and instructor survey forms served as the foundation for the study. Frequency counts on the 28-item behavioral list provided specific information on the science and gifted strategies that are being implemented in AYGS science classrooms and with what frequency they are being implemented; Likert scale responses provided a measure of instructors' and students' perceptions of the use of science reform and gifted education recommended instructional practices. Various groupings of both student and instructor responses were made to facilitate analysis of various demographic groupings required by the research questions. Chi-square analysis on the frequency counts from students' responses and teachers' responses were conducted for these various groupings.

Due to the low numbers of actual classroom observations (n=39), individual classes were not analyzed relative to all three forms (student, teacher, and classroom observation) as originally intended. Instead, the observations were combined to give an overall view of what teacher behaviors were occurring in the

classrooms; these were then compared to the frequency distribution findings of the teacher and student surveys.

Finally, the researcher looked for themes that occurred among the open-ended responses of directors, instructors, and students (Glesne & Peshkin, 1992). Individual comments were extracted to serve as representative examples of the comments made by directors, instructors, or students.

The Research Methodology Matrix in Table 2 presents the five research questions investigated by the study, the instrumentation used to explore the question, and the data analysis used to determine the results.

Table 2
Research Methodology Matrix

Research Question	Instrumentation	Data Analysis
1. How do science teachers' instructional practices vary by the following demographics: urban vs. rural location; fulltime vs. shared-time programs; teacher content area mastery vs. pedagogical certification; science ability vs. general academic ability as entry criteria for students?	<ul style="list-style-type: none"> • Director's Survey • Instructor's Survey • Science and Gifted Education Classroom Observation Form • Students' Classroom Surveys 	Descriptive Statistics Frequency Distributions Chi-Square Analysis

Research Question	Instrumentation	Data Analysis
2. What are the specific science instructional reform initiatives being employed by science teachers in specialized schools for the gifted?	<ul style="list-style-type: none"> • Science and Gifted Education Classroom Observation Form • Instructor's Survey • Students' Classroom Surveys 	Descriptive Statistics Content Analysis
3. What are the specific gifted education instructional strategies being employed by AYGS science teachers?	<ul style="list-style-type: none"> • Science and Gifted Education Classroom Observation Form • Instructor's Survey • Students' Classroom Surveys 	Descriptive Statistics Content Analysis
4. With what frequency do teachers in specialized secondary schools report using science reform instructional initiatives; with what frequency are instructional strategies for the gifted reportedly employed by these teachers?	<ul style="list-style-type: none"> • Science and Gifted Education Classroom Observation Form • Instructor's Survey • Students' Classroom Surveys 	Descriptive Statistics Frequency Distributions Chi-Square Analysis
5. What relationship exists between students', teachers', and outside observers' perceptions of science instruction in advanced science courses at AYGS?	<ul style="list-style-type: none"> • Science and Gifted Education Classroom Observation Form • Instructor's Survey • Students' Classroom Surveys 	Descriptive Information Frequency Distributions Chi-Square Analysis

Limitations and Delimitations of the Study

The interpretation and discussion of results of this study were made in light of the following constraints:

The entire population of Academic Year Governor's Schools was not selected; however, the 13 Governor's Schools participating in the study are representative, in respect to geographic location and mission, of the 15 Governor's Schools across Virginia. While one school focuses on the performing arts, the other non-participating Governor's School has a full-time program, which would have added to the data of the two other full-time programs. Since full-time programs tend to have more students, this program classification was under-represented in the total study.

The researcher, a director of a Governor's School, was a participant in the study, as was the Governor's School at which she works. Since both teachers and students were aware of this fact, the self-report data from both of these groups may not be representative of the true situation. More specially, bias of results toward a more positive or frequent use of strategies from students and teachers may

have been indicated and, perhaps, a more positive indication of the science course from students. Since the researcher was involved in the classroom observations, there may have been some bias by the researcher regarding the observed behaviors; with the researcher indicating more behaviors during observation than might be witnessed by an objective observer.

Each classroom observation was a limited view of the actual instruction that occurs in the classroom over the academic school year; a very small snapshot of instructional practices. The instructor's knowledge of the observation day may have impacted the findings. With limited observations and possible researcher impact on observation outcomes, the reader, in interpreting these findings, should be cautious in drawing conclusions.

Survey information from students and instructors was self-reported and open to personal interpretation, meaning, and bias. It is anticipated that both personal and environmental factors on the day the surveys were completed may have colored or impacted the respondents' perceptions.

For manageability, the researcher obtained classroom

observational data from only four schools. Furthermore, the researcher was able to obtain a trained individual from only two of the AYGS sites to collect the second and third classroom observations on participating teachers in order to make the study manageable. Three on-site visits by the researcher to even four Governor's schools across the state could not be feasibly accomplished within the timeframe of the dissertation process, given extreme weather conditions. The limited number of classroom observations limits the generalizability of the findings related to this study component.

CHAPTER 4

Analysis of Results

Introduction

The primary purpose of this study was to examine the use of 28 different instructional strategies by science teachers in specialized secondary schools for the gifted. These instructional strategies were selected because of their recommended use with gifted students and their recommended implementation in science instruction by national science educational organizations. In conducting the investigation, data were collected from four sources: the directors of the specialized secondary high school, the advanced-level science instructors that volunteered to be in the study, the students of the instructors that agreed to participate in the study, and a limited sample of classroom observations of some of the participating instructors.

In examining the use of the instructional strategies, the relationship between students' perceptions of the frequency with which their teacher implemented the strategy and the teachers' perceptions of the frequency of strategy implementation were explored. Various demographic data about the school and the instructors were used to further explore relationships that might influence instructional strategy implementation. Finally, qualitative comments from both instructors and students

were used to provide additional insights into the statistical findings.

There were five questions that were the focus of this study: 1) How do science teachers' instructional practices vary by the following demographics: urban vs. rural location; fulltime vs. shared-time programs; teacher content area mastery vs. pedagogical certification; and science ability vs. general academic ability as entry criteria for students?, 2) What are the specific science instructional reform initiatives being employed by science teachers in specialized schools for the gifted?, 3) What are the specific gifted education instructional strategies being employed by AYGS science teachers?, 4) With what frequency do teachers in specialized secondary schools report using science reform instructional initiatives; with what frequency are instructional strategies for the gifted reportedly employed by these teachers?, and 5) What relationship exists between students', teachers', and outside observers' perceptions of science instruction in advanced science courses at AYGS?

After initial emails were made to Academic Year Governor's School directors to ascertain their willingness to participate in the study, packets of information containing the following were sent to each director: a letter of participation and director's survey, letters of participation and instructor's survey (n = 6), a reproducible copy of the student and parent consent form, a reproducible copy of the student classroom survey form, and a postage-guaranteed Fed-ex return

envelope. All 14 possible schools were sent packets, although one school, under a new director, had not indicated willingness to participate in the study. Six of the directors received handwritten notification enclosed in the packet that indicated that their school was selected for classroom observations. The director's participation letter requested that s/he return all forms, including those from instructors and students in the enclosed Fed-ex envelope. Seven of the 14 schools replied through email that they had received the packets of information. Directors were given one month to obtain and return the completed information.

Within three weeks, three schools had returned their survey forms. One week prior to the deadline given, follow-up emails were sent to the remaining 11 schools to remind them of the deadline and to query whether they were on track with their data collection. Most of the directors replied immediately to the email. Several indicated that, while they had received completed forms from their instructors, they had not had the opportunity to collect student forms. However, plans had been made to collect the student forms in the upcoming week. Unfortunately, weather conditions throughout the state prevented many of the schools located in the north/northeast and western part of the state from attending classes. Due to the weather conditions, most of the remaining schools were unable to meet the deadline; for some schools, it was almost one month after the deadline before the forms were

submitted. During that timeframe, several follow-up emails and correspondence occurred to insure the progress of the data collection. Eventually, all schools returned the necessary information except for the one school that had never committed to participation in the study. A total of 13 schools and their directors, and 54 science instructors participated in the study.

The six schools that were slated for classroom observations were initially contacted and tentatively scheduled for visitation. Due to the weather conditions at the scheduled visitation times, only four of the six schools were visited. Of those four schools, only two indicated a willingness to assign someone the task of learning to use the SGEEO and conducting second and third classroom observations on participating teachers. The other two schools indicated that due to the fact that they had missed so many days of school, they were behind in other administrative or organizational activities that had to be addressed. In summary, all four schools had participating teachers that were observed at least once and two schools had participating teachers that were observed three times. A total of 39 observations were made across the four schools.

School and Director Demographics

The Director Surveys contained questions that ascertained personal information about the directors as well as demographic information about the schools. At the beginning of the survey, directors were asked to respond to questions about the school's focus, student population, and student selection. The results from this area of the survey were used to delineate the student and/or instructor frequency responses based on certain criteria. The following section of the survey asked directors to provide specific demographic data regarding their years at the site, their role, and their educational background. This information was used to provide additional understanding of overall findings. Finally, the directors provided insights into staff development opportunities for instructors in the areas of science education and gifted education, the role they played in providing instructional guidance, and the types of documentation used to evaluate instruction. Again, this information was used to provide additional understandings of overall findings.

Results:

Demographic information from the participating schools indicates that the number of students served by the schools were 1670 and 582 for both of the full-time high school programs down to 23 students for one shared-time rural program. Excluding these extremes, the mean number of students served by the remaining 10 shared-time program schools was 212 students. All but one school indicated that the focus of their school was math and/or science. Only one school indicated otherwise; this school indicated that Government and International Studies was its focus. Most of the schools do not reveal this strong math/science focus in their school names. Therefore, any statistical analysis by school focus/program would not be valid, given that 92% of the schools focus in math and/or science. Of the three possible location choices presented in the survey, the directors indicated that two of their schools were considered urban (15%), three schools were considered suburban (23%), and eight schools were considered rural (62%). Since the focus of the first research question deals only with urban and rural classifications, the three suburban schools, after investigation by the researcher, were reclassified to urban; thereby making the classification breakdown 38% urban and 62% rural.

The next question dealt with the selection criteria of students used by the school. Almost all of the schools indicated that they used multiple criteria in the

selection of students for the program, making it impossible to address the component of Research question #1 dealing with the academic ability of students as based on science ability or general academic ability. Nine directors indicated that the school division(s) played a role in the selection of students for the school. Most indicated that the home school division selected students for initial consideration by the AYGS for admission to the program. Only one school indicated that the districts alone had sole responsibility for selection of its students. Criteria for the school districts' selection process were not provided. Table 3 represents the student selection criteria findings.

Table 3
Student Selection Criteria

GPA	PSAT	SAT	Extra Curricular Activities	Division Selection	Strong Science/Math Background	Teacher Recommendations	Other
12 (92%)	6 (46%)	4 (31%)	6 (46%)	9 (69%)	12 (92%)	12 (92%)	4 (31%)

The comments provided by directors in the 'Other' column were as follows: principal recommendations, counselor recommendations, scores on math and writing assessments, aptitude and achievement writing samples, Naglieri Non-Verbal ability assessment, and a student observation form.

In terms of defining their role in the program, 92% of the directors indicated that they were administrators of the program. One director did not answer the question. Of the answering directors, three directors indicated that they were also instructors in the program (25%). The mean number of years for directors serving in their positions was 4.9 years with the range being from 6 months to 18 years.

All directors indicated that they had a Bachelors degree, with eight (62%) indicating a degree in a math or science background and five (38%) indicating degrees in areas unrelated to math or science. All directors indicated that they had a Master's degree. The breakdown for the Master's degree indicated that four (31%) are in math or science disciplines, six (46%) are in education/administration, and three (23%) are in Reading, Guidance, or not stated. Three of the directors (23%) indicated that they had obtained Ph.D./Ed.D.s; two in the area of Instructional Technology and one in the area of Organic Chemistry. Two of the directors indicated that they were working towards Ph.D./Ed.D.s in the area of Educational Leadership and/or Science/Curriculum. In terms of additional training in gifted education, seven (54%) indicated that they had taken additional coursework in gifted education, four (31%) indicated that they were endorsed in gifted education, one (7%) indicated that s/he had an Master's degree in gifted education, and one (7%) indicated s/he was about to receive a Ph.D. with an emphasis in gifted

education. Another question explored the additional education that directors had in the area of science education. Essentially, directors indicated that the information noted in the degree attainment section of the survey captured the information that was reported in this section. Table 4 provides an overall summary of degree attainment by the directors.

Table 4
Degree Attainment of Directors

Degree Attainment	Bachelors Degree	Master's Degree	Ph.D./Ed.D.
Degrees Overall	13 (100 %)	13 (100%)	3 (23%)
Degrees in a Math/Science Field	8 (62%)	4 (31%)	3 (23%)
Degrees in Education Field	1 (7%)	6 (46%)	0
Degree in Other Fields or Degree Focus Not Specified	4 (31%)	3 (23%)	0

A question dealing with faculty selection for the school allowed directors to check multiple options as appropriate. For options that indicate that the site has no control, a personnel department representative of the college or school division usually decides selection of faculty. Table 5 shows the percentages of schools that use stated criteria for science teacher selection.

Table 5
Science Teacher/Faculty Selection

Numbers (Percentages)	Science Teacher/Faculty Selection
6 (46%)	Based on a resume that meets minimum requirements of teaching
0	Faculty are selected by local college; site has no control
8 (62%)	As part of the interview, faculty must demonstrate knowledge of teaching skills for the selection committee
8 (62%)	Faculty has MS degree in education or science field
10 (77%)	Interview with selection committee
3 (23%)	Faculty are selected by local school division; site has no control
4 (31%)	Other (responses included – teach to students, interview with students, local schools or college makes selection after site narrows down the choices)

The second question on the survey asked directors to provide two educational goals that serve as the major foci for instruction at their school. Two directors did not respond to this question. Of the 11 responding directors, the most common responses dealt with issues of curriculum for students of a specialized school (48%). Another frequent response dealt with the integration of technology into instruction (17%). Finally, the application of concepts/knowledge (13%), provision of social climate (13%), and the promotion of problem-solving skills (9%) completed the

responses. Table 6 below provides a detailed accounting of the directors' responses regarding their school foci.

Table 6
Directors' Responses Regarding School Foci

School	Directors' Responses Regarding School Foci
1	The integration of technology as an instructional tool and the integration of a research-based approach in math and science classes.
2	Building a community of learner and the application of knowledge/concepts within the instructional approach.
3	Develop problem-solving skills and provide educational hands-on experience in marine/environmental science that will have direct impact on our local resources.
4	Teach advanced course work and the integration of advanced gifted learning with regular education instruction.
5	Develop an integrated curriculum and apply communication skills and math and science knowledge to real-life problem-solving opportunities.
6	Content studies as related to actual practice of academic disciplines and the use of primary resources for content is preferred.
7	Continued success at 100% pass-rate on all end-of-course tests and to continue in the use of technology for instructional purposes.
8	Accelerated, challenging curriculum in all four subject areas: English, math, science, social science, and the integration of these disciplines, of technology and of community-enhanced instructional experiences into the curriculum.
9	Prepare students for all areas of study and provide students with both curriculum and co-curricular opportunities that support the mission of the school.
10	Teaching fundamentals of research and the integration of technology across the curriculum.
11	Academically challenges students and supports peer group interaction.
(Two directors did not respond to this question)	

The next five questions on the survey pertained to issues surrounding staff evaluation and staff development. For the third question on the survey, all schools

indicated some form of documentation was used to evaluate instructional practices. Seven of the directors indicated that they use multiple methods to document instruction. Five directors (38%) indicated that they use scripting of the classroom observation; ten directors (77%) indicated they use a checklist as an observational tool; two directors (15%) noted that they use videotapes to capture and evaluate instruction; and four directors (31%) indicated that they use teacher portfolios in the documenting of instructional practices. Five directors indicated additional options were used to evaluate instruction. Two directors (15%) reported using student survey/observation forms while each of the remaining three directors mentioned one (7%) of the following: spatial analysis; team on-line evaluation, and review of records. In summary, the majority of AYGS use multiple measures to evaluate instructional practices.

Table 7 below provides insights into Questions 4, 5, 6, and 7 on the survey. These questions deal with the frequency of staff development opportunities over the past three years in science education and gifted education, as well as the types of staff development services offered at those sessions. A summary look at these questions reveals a difference between the staff development opportunities presented in science education versus those presented in gifted education. In essence, science staff development opportunities occur more often (usually 2-4

times per year, 38% responses) and tend to focus on the integration of technology into instruction (84%) and the development of inquiry-based labs (62%), whereas gifted education staff development opportunities usually occur only once per year (38%) and tend to focus on a variety of topics (three topics at the highest percentage of 46% - integration of technology, hands-on approaches, and grouping strategies). As a final comment, it should be noted that two directors did not comment on the science questions and that three directors did not comment on the gifted questions; however, percentages were computed based on the entire sample size.

Table 7
Staff Development Opportunities Presented

Opportunity	Science Education	Gifted Education
No opportunities for staff development over the past three years	15%	15%
One staff development session annually	23%	38%
2-4 staff development sessions annually	31%	7%
5-7 staff development sessions annually	7%	7%
8+ staff development sessions annually	0	0
Other (paid course work; teachers select their own; discussion at faculty meetings)	15%	31%

Opportunity	Science Education	Gifted Education
In-service on integrating technology	84%	46%
In-service on questioning strategies	38%	38%
In-service on concept mapping	23%	7%
In-service on PBL – problem-based learning	31%	38%
In-service on project-based work	46%	23%
In-service on problem-solving	31%	31%
In-service on hands-on approaches	46%	46%
In-service on developing inquiry-based labs	62%	23%
In-service on inquiry approach	23%	23%
In-service on interdisciplinary perspectives	46%	46%
In-service on grouping strategies	31%	38%
In-service on other: learner characteristics	0	7%

Finally, Question #8 asked directors to comment on their role in providing instructional guidance to instructors. All directors responded to this question, indicating some level of participation in providing guidance. The majority of directors were involved in dedicating funds to support conference travel (n = 12, 92%), were available upon request to discuss instructional issues (n = 11, 84%), and conducted classroom observations and provided critique (n = 12, 92%). Only two directors (15%)

indicated that they teach a class as a model for instructional practice, and only four directors (31%) indicated that they teach a class regularly. In contrast, nine directors (69%) indicated they discuss instructional methods at faculty meetings while six directors (46%) stipulated that they determine all staff development and in-service opportunities.

Instructor Demographics and Survey

The Instructor's Survey served to gather demographic data on 54 teachers that participated in the study and to ascertain their perceptions of their use of 28 instructional strategies. The first page of the survey form asked respondents to supply demographic data on their position, years of service at that site, years of service at other schools, total years teaching, total years teaching science, total years working with academically gifted students, grade level assignment, and the current course(s) they were teaching.

The next section of the survey required instructors to indicate their degrees and any special certificates or endorsements. Additional sections dealt with the instructors' participation over the past three years in science education or gifted education opportunities.

On the following pages of the survey, instructors were presented with a 28-question survey of a variety of instructional practices in the categories of general teaching strategies, problem-solving strategies, critical thinking strategies, metacognition, and science reform indicators. Instructors were to indicate a particular course that the survey was being completed for and then assign a value to each strategy according to how often they implemented the strategy in their classroom. A final section was labeled 'Other Comments' for teachers to make open remarks, as they deemed appropriate.

Results:

Representing the thirteen participating schools in the study were 54 science teachers of advanced science courses, predominately comprised of 11th and 12th grade students. Of the five science disciplines represented in the study, physics instructors accounted for 34% of the respondents (n =18), biology instructors accounted for 29% of the respondents (n =16), chemistry instructors accounted for 17% of the respondents (n =9), environmental science instructors accounted for 15% of the respondents (n =8), and advanced research/technology instructors accounted for 5% of the respondents (n =3). Collectively, the instructors had a mean of 7.5 years teaching at their site, with a range of service from 6 months to 18 years. They

averaged a total of 8.3 years teaching at other sites and a total mean time in the teaching profession of 17.2 years. Closely related to this average was the mean for the number of years instructors spent teaching science (16.9 years). The mean of the years instructors spent teaching gifted students was 11.7 years.

Based on the wording of the question, it appears that the instructors were educated in science as opposed to education at the Bachelors level. However, we cannot know this for sure. At the Master's level, 87% of the respondents had degrees, of which 36 (67%) were in a science or math-related field, and 11 (20%) were in the field of education. Sixteen instructors (30%) had their Ph.D./Ed.D., with 14 (26%) instructors having degrees in a science or math field and two (4%) having degrees in education. In addition, 29 instructors (54%) had either degrees or certification in gifted education. Table 8 reflects these findings.

Table 8
Degree Attainment of Instructors

	Bachelors Degree	Master's Degree	Ph.D./Ed.D.
Degrees Overall	54 (100 %)	47 (87%)	16 (30%)
Degrees in a Math/Science Field	54 (100%)	36 (67%)	14 (26%)
Degrees in Education Field	0	11 (20%)	2 (4%)
Degree in Other Fields or Degree Focus Not Specified	0	0	0

In the subsequent sections of the survey, instructors were to indicate their participation in additional training opportunities in both science education and gifted education. For clarification, the term 'in-service' refers to sessions that usually contain multiple topics in a lecture-oriented presentation, and the term 'workshop' refers to a session that usually focuses on one topic area with a hands-on component for the development of materials or the useful practice of materials related to the topic. According to the percentages, the most attended science education opportunity was a state/national conference (72%), with attendance at a school-sponsored teacher in-service (57%) as their second most attended event. For the most attended gifted education opportunity, instructors selected a school-sponsored teacher in-service (44%), with attendance at faculty meetings to discuss educational practices (41%) selected as their second most attended event. Attendance at state/national conferences, while the most selected response in science education, was selected by 33% of the instructors when it pertained to gifted education. In the category that states there was no opportunity for staff development over the past three years, 5% of the instructors indicated this was the case for science education and 15% of the instructors indicated this was the case for gifted education. In every category of opportunity except this one, instructors

participated less often in gifted education opportunities than in science education.

Table 9 reflects these findings.

Table 9

Staff Development/Training Opportunities Attended

Opportunity	Science Education	Gifted Education
No opportunities for staff development over the past three years	3 (5%)	8 (15%)
Attendance at local/national conferences	39 (72%)	18 (33%)
Additional college/university courses	26 (48%)	8 (15%)
School-sponsored teacher in-service	31 (57%)	24 (44%)
Mentor/peer guidance	17 (31%)	9 (17%)
Faculty meetings to discuss educational practices	25 (46%)	22 (41%)
School-sponsored teacher workshops	22 (41%)	13 (24%)
College or organization sponsored teacher workshops	26 (48%)	8 (15%)
Other – PTA speaker on G/T	0	1 (2%)

The largest component in the instructors' survey was the 28-item questionnaire that asked teachers to assign a value to each of the items. Some teachers did not respond to all of the 28 items, occasionally indicating they did not understand a word or the wording of the statement. Instructors were asked to

assign one of the following values to the instructional practices as implemented in their science classroom: 1 = not at all; 2 = a few times a year; 3 = once every couple of months; 4 = once or twice a month; 5 = at least once a week; 6 = daily. All responses on the questionnaire were analyzed for frequency counts. On many of the items, the majority of teachers assigned frequency values of range of 3 to 6, and few, if any, teachers assigned values of 1 to 2. Table 10 reflects these results.

Table 10
Instructors' Responses to the 28-Item Survey

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	RESPONSE FREQUENCY GIVEN AS PERCENTAGES					
			1 not at all	2 annually	3 bimonthly	4 monthly	5 weekly	6 daily
General Teaching Strategies	1	Uses flexible patterns of grouping students when delivering a lesson	9.3	11.1	9.2	31.5	24.1	14.8
	2	Presents the lesson in several ways	1.8	1.8	5.6	22.2	50.0	18.6
	3	Provides activities for students to apply knowledge to new situations	0	1.8	1.8	26.0	61.1	9.3
	4	Provides the opportunity for students to use technology	0	0	2.3	14.0	37.2	46.5
	5	Uses hands-on approaches, such as journals, experiments, & manipulatives	0	1.9	0	22.2	68.5	7.4
	6	Uses cooperative or collaborative learning strategies	0	1.8	9.4	37.8	37.8	13.2

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	RESPONSE FREQUENCY GIVEN AS PERCENTAGES					
			1 not at all	2 annually	3 bimonthly	4 monthly	5 weekly	6 daily
Problem Solving Strategies	7	Allows students to discover central ideas on their own through activities and/or questions	1.9	7.4	11.1	27.8	37.0	14.8
	8	Emphasizes higher level thinking strategies/skills	0	1.8	0	1.8	50.0	46.4
	9	Uses activities or questions which allow students to brainstorm ideas or alternatives	0	14.8	7.4	33.4	33.4	11.0
	10	Uses activities or questions which allow students to define problems	1.9	11.5	11.5	36.6	28.9	9.7
	11	Uses activities or questions which allow students to develop, select, and implement solutions to problems	3.7	9.3	16.7	20.4	27.8	22.2
	12	Uses activities or questions which allow students to explore multiple interpretations	3.7	11.1	18.5	42.6	20.4	3.7
	13	Uses activities or questions which allow students to use alternative modes of expressions for their work (charts, graphs, videos, art, music, journals, etc)	7.4	14.8	11.1	29.6	31.5	5.6
	14	Uses activities or questions which allow students to self-select topics for further investigation	13.0	35.2	14.8	25.9	9.3	1.8
	15	Provides opportunities for students to make judgments or evaluate situations or issues	0	17.0	18.9	26.4	24.5	13.2
	16	Provides opportunities for students to compare and contrast	0	3.8	5.6	32.1	39.6	18.9
Critical Thinking Strategies								

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	RESPONSE FREQUENCY GIVEN AS PERCENTAGES					
			1 not at all	2 annually	3 bimonthly	4 monthly	5 weekly	6 daily
Metacognition	17	Provides opportunities for students to generalize from specific data to the abstract	3.7	3.7	11.1	29.6	31.5	20.4
	18	Provides opportunities for students to synthesize or summarize information across or within disciplines	3.7	7.4	14.8	26.0	29.6	18.5
	19	Provides opportunities for students to debate points of view or develop arguments to support ideas	9.3	22.2	24.1	20.4	14.8	9.2
	20	Models metacognitive strategies such as planning, monitoring, self-reflection or self-appraisal for the student	19.6	27.5	11.8	13.7	17.6	9.8
	21	Provides opportunities for students to think about their own thinking	11.5	17.3	17.3	19.2	19.2	15.4
	22	Provides opportunities for students to reflect on their own performance	5.6	20.4	14.8	16.7	29.6	12.9
	23	Uses major concepts (e.g.; systems, change, models, patterns) to focus learning	0	5.7	11.3	20.8	26.4	35.8
	24	Emphasizes the research process within an integrated framework (e.g.; exploring a topic, planning how to study it and carrying out a study, judging the results, and reporting)	5.7	9.4	18.9	39.6	18.9	7.5
	25	Uses substantive content for the course and grade level	1.9	0	1.9	3.9	27.5	64.8
	26	Uses inquiry-oriented instruction	5.6	5.6	9.2	37.0	22.2	20.4

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	RESPONSE FREQUENCY GIVEN AS PERCENTAGES					
			1 not at all	2 annually	3 bimonthly	4 monthly	5 weekly	6 daily
	27	Uses activity-based instruction, engaging students in the doing and learning of science	0	0	1.9	27.8	48.1	22.2
	28	Structures opportunities for students to discuss real-world problems and issues as they relate to the science content	0	11.1	20.4	20.4	35.2	12.9

Further discussion of teacher assignment of frequency values versus students' assignment of frequency values is addressed under the research questions in this chapter.

In the open comments section following the questionnaire, of the eight instructors (15%) that made comments, four indicated that they had left some items blank because they did not understand what was referenced in the statement. Two indicated that they were not sure students understood the statements. The other remaining two comments provided additional information on the structure of the teacher's course, i.e. the length of class time/frequency of meeting days and a detailed report on the planning and structure of the course/program.

Student Demographics and Survey

The student classroom surveys were distributed to the science students of the participating instructors. A total of 1190 students participated in the study. At the beginning of the survey, students were asked to complete demographic information that dealt with the number of years they had attended the Governor's School, their current grade level, science courses they were taking, and the science course that the survey reflected.

On the following pages of the survey, students were presented with a 28-question survey of a variety of instructional practices in the categories of general teaching strategies, problem-solving strategies, critical thinking strategies, metacognition, and science reform indicators. Students were to indicate a particular course that the survey was being completed for and to assign a value to each strategy according to how often they observed the teacher implementing the strategy in the classroom. A third question in the survey asked students to compare the instructional strategies used in this class to those strategies used in a better taught science class (in their opinion). A final section was labeled 'Other Comments' for students to make open remarks, as they deemed appropriate.

Results:

In general, the majority of respondents were in the second year of attending the Governor's school (n = 445), taking one science course (n = 556), and in 11th grade (735). The remaining students were in their first (n = 425), third (n = 165), or fourth (n = 155) year of attendance, were taking two (n = 434) or three (n = 200) science courses and were either in 10th (n = 91) or 12th (n = 364) grades. The first question in the survey asked students about the expectations they had for instructional practices in the class (see Appendix I for samples of specific student responses). Each student response (n = 1071) was read. Statements were analyzed, broken into their component sentences or word fragments, and sorted into one or more categories (Glesne & Peshkin, 1992). Categories were further redefined and sorted until a central idea or theme was the focus of the data in that category. Not all students responded to this question. Many students responded with more than one statement that was reflective of the several themes.

The themes of the responses fell into the following categories: higher-level content, lab work/hands-on, to be challenged, to be able to understand what is happening in the world, fun learning experience, to be prepared for college, and specific expectations of the course. These themes relate to such instructional practices as labs/hands-on, applications to real world, higher-level thinking, and

substantive content. A few responses centered on specific expectations of the course, not the instructional practices; general statements about learning to solve a particular problem, to learn a certain skill, or to get an A for the course. Table 11 depicts these major thematic categories.

Table 11
Students' Responses by Thematic Category to Instructional Expectations

RESPONSE CATEGORY	PERCENTAGE OF RESPONSES
Higher-level content	43
Lab work/hands-on activities	26
To be challenged	16
To be able to understand what is happening in the world	8
A fun learning experience	4
To be prepared for college	2
Specific expectations (such as: solve a certain problem, get an A, learn a certain skill)	1

The largest component in the students' survey was the 28-item questionnaire that asked students to assign a value to each of the items. Some students did not respond to all of the 28 items, occasionally indicating they did not understand a word or the wording of the statement. Students were asked to assign one of the following values to the instructional practices they observed in their science classroom: 1 = not at all; 2 = a few times a year; 3 = once every couple of months; 4 = once or twice

a month; 5 = at least once a week; 6 = daily. All responses on the questionnaire were analyzed for frequency counts. On all of the items, the students assigned frequency values that ranged from 1 to 6. Table 12 reflects the results of 1190 student surveys.

Table 12
Students' Responses to the 28-Item Survey

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	RESPONSE FREQUENCY GIVEN AS PERCENTAGES					
			1 not at all	2 annually	3 bimonthly	4 monthly	5 weekly	6 daily
General Teaching Strategies	1	Uses flexible patterns of grouping students when delivering a lesson	14.5	13.0	12.7	23.6	21.6	14.6
	2	Presents the lesson in several ways	5.1	10.3	11.0	20.7	33.1	19.8
	3	Provides activities for students to apply knowledge to new situations	1.8	5.1	7.7	28.8	40.5	16.1
	4	Provides the opportunity for students to use technology	1.2	2.8	6.7	20.4	35.3	33.6
	5	Uses hands-on approaches, such as journals, experiments, & manipulatives	1.6	2.9	6.4	27.0	50.8	11.3
	6	Uses cooperative or collaborative learning strategies	4.7	8.3	12.8	24.1	31.4	18.7
	7	Allows students to discover central ideas on their own through activities and/or questions	4.4	7.3	7.0	18.9	31.0	31.4
	8	Emphasizes higher level thinking strategies/skills	1.5	2.6	8.7	15.8	26.7	44.7

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	RESPONSE FREQUENCY GIVEN AS PERCENTAGES					
			1 not at all	2 annually	3 bimonthly	4 monthly	5 weekly	6 daily
Problem Solving Strategies	9	Uses activities or questions which allow students to brainstorm ideas or alternatives	6.7	6.6	11.1	25.3	29.4	20.9
	10	Uses activities or questions which allow students to define problems	7.2	3.6	14.1	22.3	33.1	19.7
	11	Uses activities or questions which allow students to develop, select, and implement solutions to problems	5.8	5.3	12.1	22.4	31.8	22.6
	12	Uses activities or questions which allow students to explore multiple interpretations	5.2	9.0	17.7	25.1	27.0	16.0
	13	Uses activities or questions which allow students to use alternative modes of expressions for their work (charts, graphs, videos, art, music, journals, etc)	10.0	11.3	14.4	28.7	24.9	10.7
	14	Uses activities or questions which allow students to self-select topics for further investigation	16.1	19.4	20.9	22.7	12.6	8.3
	15	Provides opportunities for students to make judgments or evaluate situations or issues	5.1	7.8	15.5	25.7	28.6	17.3
Critical Thinking Strategies	16	Provides opportunities for students to compare and contrast	3.4	8.1	15.4	24.5	29.4	19.2
	17	Provides opportunities for students to generalize from specific data to the abstract	5.4	6.7	18.4	32.0	24.5	13.1
	18	Provides opportunities for students to synthesize or summarize information across or within disciplines	5.5	8.2	17.9	25.8	28.1	14.5

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	RESPONSE FREQUENCY GIVEN AS PERCENTAGES					
			1 not at all	2 annually	3 bimonthly	4 monthly	5 weekly	6 daily
Metacognition	19	Provides opportunities for students to debate points of view or develop arguments to support ideas	15.6	13.2	15.9	18.3	19.9	17.1
	20	Models metacognitive strategies such as planning, monitoring, self-reflection or self-appraisal for the student	15.3	13.2	13.8	25.3	20.5	11.8
	21	Provides opportunities for students to think about their own thinking	11.2	10.1	15.8	17.9	22.5	22.5
	22	Provides opportunities for students to reflect on their own performance	8.8	13.4	12.2	21.1	27.0	17.5
	23	Uses major concepts (e.g.; systems, change, models, patterns) to focus learning	3.1	4.7	12.8	22.9	28.2	28.3
Science Reform Indicators	24	Emphasizes the research process within an integrated framework (e.g.; exploring a topic, planning how to study it and carrying out a study, judging the results, and reporting)	7.6	9.7	17.3	21.2	25.0	15.2
	25	Uses substantive content for the course and grade level	0.7	4.2	6.0	11.3	25.3	52.5
	26	Uses inquiry-oriented instruction	3.5	6.1	10.0	17.1	32.7	30.6
	27	Uses activity-based instruction, engaging students in the doing and learning of science	1.8	4.8	10.4	24.4	37.7	20.9
	28	Structures opportunities for students to discuss real-world problems and issues as they relate to the science content	5.8	6.8	16.7	18.9	30.8	21.0

Further discussion of teacher assignment of values versus students' assignment of values is addressed under the Research Question #4 in this chapter.

Several themes emerged in the open-ended Question #3 regarding how the instructional practices in this class (Governor's School) compare to other science courses they had taken. Statements were analyzed, broken into their component sentences or sentence fragments, and sorted into one or more categories (Glesne & Peshkin, 1992). Categories were further defined and sorted until a central idea or theme was the focus of the data in that category. Not all students responded to this question (n = 1094).

The most common themes that emerged indicated that the students' current science course had more labs, dealt with more higher-level content, incorporated more application of knowledge, incorporated more connections with real-world or relevant issues, required more independent learning, moved at a good but fast pace, incorporated more technology, that the instructor was knowledgeable of the subject, and the instructor was always willing to help. Next, responses centered on statements such as, 'It is the best course ever.' and ' I do not like this course.' Table 13 reflects these results. A sample of detailed responses may be found in Appendix I.

Table 13***Student Responses by Thematic Category to Comparison of Science Courses***

RESPONSE CATEGORY	PERCENTAGE OF RESPONSES
More lab work/hands-on activities	32
More higher-level content	21
More application of knowledge/concepts	14
Incorporates more real-world, relevant issues	10
Requires more independent learning	9
Good but faster pace	6
Incorporates more technology	5
Instructor is knowledgeable of subject	1
Instructor is willing to help	1
I like/dislike this course	1

Question #4 was open-ended for students to write whatever comments they wanted to make. Rarely was this question answered ($n = 214$). Of the comments that were made (a sample of these responses can be found in Appendix I), most pertained to the format of the survey (76%), with many students commenting that they did not completely understand the questions or the terms, especially the word "metacognition." Some answers were blanket comments about whether they liked or disliked the teacher (18%). A few comments indicated that the instructional

strategies given in the survey were not relevant to science instruction (3%). Finally, a few comments addressed issues of education in general (3%).

Classroom Observation Data

Classroom observations were conducted at four schools participating in the study. Two schools were in urban locations and two schools were in rural locations. The SGEEO form was used to record the classroom observations. A total of 39 observations were made for the study. Ten of the instructors were observed three times and 9 of the instructors were observed once. The researcher conducted the initial observation of each instructor. Second and third observations of the ten instructors was conducted by a trained administrator or assistant in the manner described in the methodology section. Instructors were notified of the dates and times of the initial observation in advance. Each observation lasted approximately 30 minutes.

Results:

Since the observation was only a small snapshot of the actual teaching that occurs in the classroom over the course of the year, many of the behaviors on the SGEEO form were rarely observed. By aggregating the observations in the five

categories of behaviors, the researcher was able to discern areas of frequent implementation and areas of less frequent implementation. Given that some categories have more opportunities for observations of behaviors, a scale was derived by assuming one observation occurred in each item and by figuring the percentage of observations expected to occur in that category. The expected percentages were as follows: 29% general teaching strategies, 21% problem-solving, 18% critical thinking, 11% metacognition, and 21% science reform indicators. Actual observations, when compared to the expected observations, indicated strengths in the areas of general teaching strategies and science reform indicators. Problem-solving and critical thinking were slightly below expected percentages, while metacognitive strategies were very low. The total number of observed behaviors during the 39 observations was 257. The following table (Table 14) provides the percentages of the observations by category.

Table 14
Percentages of the Observations By Category

Category	Actual Observations	Percentage of 257 Indications
General Teaching Strategies	103	40
Problem-solving	41	16
Critical Thinking	30	12

Category	Actual Observations	Percentage of 257 Indications
Metacognition	10	4
Science reform Indicators	73	28

Regarding the observations on an individual item basis, only one item - item 25 that addresses substantive content - was noticed in all 39 observations. Several items had only three or less observations: allows students to use alternative modes of expression; allows students to self-select topics for further investigation; allow students to debate points of view; allow students to think about their thinking; models metacognitive strategies; focuses learning on concepts. All other items show some level of observation between five through 16. Table 15 reflects these data.

Table 15
Observational Data by Item

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	ACTUAL OBSERVATIONS (N=39)
General Teaching Strategies	1	Uses flexible patterns of grouping students when delivering a lesson	12
	2	Presents the lesson in several ways	14
	3	Provides activities for students to apply knowledge to new situations	16
	4	Provides the opportunity for students to use technology	12

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	ACTUAL OBSERVATIONS (N=39)
Problem Solving Strategies	5	Uses hands-on approaches, such as journals, experiments, & manipulatives	12
	6	Uses cooperative or collaborative learning strategies	14
	7	Allows students to discover central ideas on their own through activities and/or questions	12
	8	Emphasizes higher level thinking strategies/skills	11
	9	Uses activities or questions which allow students to brainstorm ideas or alternatives	11
	10	Uses activities or questions which allow students to define problems	10
	11	Uses activities or questions which allow students to develop, select, and implement solutions to problems	10
	12	Uses activities or questions which allow students to explore multiple interpretations	5
	13	Uses activities or questions which allow students to use alternative modes of expressions for their work (charts, graphs, videos, art, music, journals, etc)	2
	14	Uses activities or questions which allow students to self-select topics for further investigation	3
	15	Provides opportunities for students to make judgments or evaluate situations or issues	8
	16	Provides opportunities for students to compare and contrast	5
	17	Provides opportunities for students to generalize from specific data to the abstract	9
	18	Provides opportunities for students to synthesize or summarize information across or within disciplines	6
Metacognition	19	Provides opportunities for students to debate points of view or develop arguments to support ideas	2
	20	Models metacognitive strategies such as planning, monitoring, self-reflection or self-appraisal for the student	2
	21	Provides opportunities for students to think about their own thinking	2

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	ACTUAL OBSERVATIONS (N=39)
Science Reform Indicators	22	Provides opportunities for students to reflect on their own performance	6
	23	Uses major concepts (e.g.; systems, change, models, patterns) to focus learning	2
	24	Emphasizes the research process within an integrated framework (e.g.; exploring a topic, planning how to study it and carrying out a study, judging the results, and reporting)	6
	25	Uses substantive content for the course and grade level	39
	26	Uses inquiry-oriented instruction	6
	27	Uses activity-based instruction, engaging students in the doing and learning of science	9
	28	Structures opportunities for students to discuss real-world problems and issues as they relate to the science content	11

Further investigation into the actual number of observed behaviors per individual teacher revealed a range between 1 - 17 behaviors per 30 minute observation, with a mean of 7 observed behaviors. An examination of multiple observations for those teachers who were observed several times did not suggested a pattern of implementation. For example, one teacher had observed behaviors of 17, 4, and 9 for his/her three observations. Likewise, the observed behaviors noted for teachers with multiple observations did not show a pattern of the same behaviors being implemented each time, with the exception of Item #25 dealing with substantive content. These observation results are discussed in the appropriate

research questions in relationship to other findings from student and instructor surveys.

Initial Data Comparisons

Both teacher and student Likert scale data responses from the 28-item questionnaire were compiled to determine frequency of responses by group by question. Frequency counts for every question/behavior for both groups were loaded into a database. Chi-square analyses between teacher and student frequency counts were computed, grouping all teachers together and all students together. The resulting Chi-square values indicated significant differences did not exist in the frequency with which teachers implemented and students observed instructional behaviors; essentially, students' and teachers' perceptions of the frequency with which instructional behaviors were being used in the classroom were the same. However, these statistical results should be reviewed cautiously due to the fact that the sheer number of student responses may mask any extreme responses that were reported.

Research Question #1: How do science teachers' instructional practices vary by the following demographics: urban vs. rural location; fulltime vs. shared-time

programs; teacher content area mastery vs. pedagogical certification; science ability vs. general academic ability as entry criteria for students?

Chi-square analyses of the frequency of teacher responses by item were used to answer this question. Teacher responses were subdivided by the various subgroups. As stated in earlier sections of this chapter, resulting demographic data would not allow for the subdivision of teachers or students into the following categories: fulltime vs. shared-time programs (only 2 schools were fulltime programs) and science ability vs. general academic ability as entry criteria for students (all schools but one indicated a science ability selection criteria). However, subdivisions were made by urban vs. rural location and teacher content area mastery vs. pedagogical certification.

Teacher frequency data were subdivided by urban location versus rural location. Chi-square analysis was conducted on the resulting comparisons. Results showed no significant difference in teachers' perceptions of instructional strategy implementation in science classrooms. Using the same methodology, but subdividing teacher frequency data by teacher content area mastery versus teachers with pedagogical certification yielded similar results; no significant difference between teacher subgroups.

An examination of student reported frequency data subdivided by urban versus rural schools and subdivided by teacher content area mastery versus teachers with pedagogical certification yielded some significant results. The urban designation is representative of 694 students (58%) of 25 teachers. The rural designation is representative of 496 students (42%) of 29 teachers. The teacher content mastery designation applied to teachers with only degrees in their subject field (this group may include those certified to teach math or science); no additional certifications or degrees in education were reported. Responses from students of the 24 teachers under this designation were 501 (42%). The teacher pedagogical certification designation applied to teachers with either degrees in an educational field or degrees in their content area with additional certification in gifted education. Responses from students of the 30 teachers under this designation were 689 (58%).

Analysis between students' perceptions of urban school teachers and students' perceptions of rural school teachers indicates that there is a significant difference in the way students perceive teachers' implementation of instructional strategies. In general, the majority of the chi-square value is comprised of differences between students from rural schools frequency counts and the expected frequency count values of those students. This indicated that rural students' actual counts are lower

on certain frequencies per item than was expected. In contrast, students from urban settings gave higher frequency counts than the chi-square expected values. Overall, instructional strategy categories showing the most difference between student frequency counts in urban settings versus rural settings were within general teaching strategies, critical thinking strategies, and science reform indicators. In general, these findings indicate that rural students tended to report less frequent use of instructional strategies than would be expected and students from urban settings tended to indicate more frequent use of instructional strategies than would be expected.

Similarly, several strategy items of the comparison between perceptions from students of content mastery teachers and perceptions from students of teachers with pedagogical certification showed significant difference. Overall, more significant difference was found for general teaching strategies than any other category, with each item showing significance. Closer examination indicates that, on average, students of mastery content teachers rated strategy implementation use at a higher frequency than chi-square expected values. Similar differences occurred in the category of metacognitive strategies, but not to the same degree as general teaching strategies. Other categories had some items of significance, mainly attributed to students of mastery content teachers rating strategy implementation

at a higher frequency than chi-square expected values. In general, findings indicate that students of content mastery teachers viewed strategy implementation by their teacher at a significantly higher frequency rating than expected, while students of teachers with pedagogical certification rated their teachers lower than expected. All Chi-square results reported in the following table (Table 16) have a Degrees of Freedom value equal to five (DF=5).

Table 16
Chi-square Comparisons on Subdivided Student Frequency Data

ITEM #	INSTRUCTIONAL BEHAVIOR	Urban vs. Rural		Content Mastery vs. Pedagogical Certification	
		X ²	p	X ²	p
1	Uses flexible patterns of grouping students when delivering a lesson	52.475	0.000	35.863	0.000
2	Presents the lesson in several ways	27.302	0.000	15.113	0.010
3	Provides activities for students to apply knowledge to new situations	26.218	0.000	28.689	0.000
4	Provides the opportunity for students to use technology	40.374	0.000	17.458	0.004
5	Uses hands-on approaches, such as journals, experiments, & manipulatives	40.356	0.000	26.960	0.000
6	Uses cooperative or collaborative learning strategies	123.118	0.000	29.994	0.000
7	Allows students to discover central ideas on their own through activities and/or questions	20.688	0.001	20.590	0.001
8	Emphasizes higher level thinking strategies/skills	13.508	0.019	12.697	0.026
9	Uses activities or questions which allow students to brainstorm ideas or alternatives	11.471	0.043	4.551	0.473
10	Uses activities or questions which allow students to define problems	6.924	0.226	12.044	0.034

ITEM #	INSTRUCTIONAL BEHAVIOR	Urban vs. Rural		Content Mastery vs. Pedagogical Certification	
		X ²	p	X ²	p
11	Uses activities or questions which allow students to develop, select, and implement solutions to problems	2.121	0.832	10.808	0.055
12	Uses activities or questions which allow students to explore multiple interpretations	11.849	0.037	19.695	0.001
13	Uses activities or questions which allow students to use alternative modes of expressions for their work (charts, graphs, videos, art, music, journals, etc)	22.525	0.000	24.531	0.000
14	Uses activities or questions which allow students to self-select topics for further investigation	8.874	0.114	12.803	0.025
15	Provides opportunities for students to make judgments or evaluate situations or issues	21.495	0.001	8.923	0.112
16	Provides opportunities for students to compare and contrast	19.019	0.002	6.000	0.306
17	Provides opportunities for students to generalize from specific data to the abstract	21.277	0.001	18.446	0.002
18	Provides opportunities for students to synthesize or summarize across/within disciplines	22.056	0.001	8.023	0.155
19	Provides opportunities for students to debate points of view or develop arguments to support ideas	11.939	0.036	18.009	0.003
20	Models metacognitive strategies such as planning, monitoring, self-reflection or self-appraisal for the student	6.693	0.245	18.119	0.003
21	Provides opportunities for students to think about their own thinking	7.680	0.175	8.277	0.142
22	Provides opportunities for students to reflect on their own performance	17.094	0.004	18.203	0.003
23	Uses major concepts (e.g.; systems, change, models, patterns) to focus learning	17.107	0.004	2.016	0.847
24	Emphasizes the research process within an integrated framework (e.g.; exploring a topic, planning how to study it and carrying out a study, judging the results, and reporting)	18.826	0.002	9.792	0.081
25	Uses substantive content for the course and grade level	Invalid; counts less than 5		Invalid; counts less than 5	
26	Uses inquiry-oriented instruction	5.329	0.377	2.051	0.842
27	Uses activity-based instruction, engaging students in the doing and learning of science	37.108	0.000	34.633	0.000

ITEM #	INSTRUCTIONAL BEHAVIOR	Urban vs. Rural		Content Mastery vs. Pedagogical Certification	
		X ²	p	X ²	p
28	Structures opportunities for students to discuss real-world problems and issues as they relate to the science content	30.308	0.000	17.178	0.004

Research Question #2: What are the specific science instructional reform

initiatives being employed by science teachers in specialized schools for the gifted?

The second research question examines the instructional behaviors addressed in Items 23-28 of the surveys and classroom observation forms, specifically science reform indicators. As an educational researcher, I reasoned that regular employment of a strategy required a frequency basis of 'weekly' or 'daily'. Moreover, given that these schools are specialized schools for gifted students and most have a focus in science education, there is an expectation that these strategies would be occurring regularly in all schools; a combined weekly and daily frequency count of 100%. Allowing for some degree of less frequent use, for the purpose of this analysis, the strategy is considered 'routinely' or 'frequently' used if 90% or more of the responses were indicated in the weekly or daily counts (indicating a 'routinely' or 'frequently' used rating from 90% or more of the participants across the 13 schools in the study).

If frequent usage as indicated by 90% of respondents (both teachers and students) is the criterion for determining if a strategy is being employed by science teachers in specialized schools for the gifted, then not a single item in the science reform indicators was being regularly employed by instructors in AYGS in Virginia. However, teachers and students indicated that strategies were being utilized, but not in 90% or more of the participating classrooms. Some strategies fell slightly below the 90% qualification, while other strategies fell far below. A closer examination of frequency implementation follows below.

The only strategy teachers indicated that they used on a frequent basis across all schools was the use of substantive content for the course and grade (92.3%). While students rated this strategy at a high level (77.8%), it was not at the 90% or greater value to be deemed 'frequently' used. About three-quarters of the teachers indicated that they frequently use activity-based instruction (70.3%), while just over half of the students (58.6%) indicated that teachers frequently use this approach. On the use of concepts as the focus for instruction, over half of the teachers (62.2%) and students (56.5%) rated these at a high frequency. Considering the use of research process skills, only 26.4% of the participating teachers across the schools indicated that they used this strategy on a frequent basis. While more students (40.2%) indicated they saw frequent usage of research skills, they still

encompassed less than half of the study's student participants. Similarly, less than half of the teachers indicated they used inquiry-based instruction (42.6%) or they related science content to real-world problems (48.1%). Students reported slightly higher usage of inquiry-oriented instructional strategies (63.3%) and application to real-world problems (51.8%) by their teachers.

Table 17 below depicts the usage of science reform indicators on a regular basis (weekly and daily responses of '5' and '6'), with instructors' and students' responses for those frequency counts collapsed as a percentage.

Table 17
Instructors' and Students' Responses for Weekly and Daily Frequencies of Science Reform Indicators Collapsed as a Percentage

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	INSTRUCTORS' 'WEEKLY' & 'DAILY' RESPONSES COMBINED AS A PERCENTAGE	STUDENTS' 'WEEKLY' AND 'DAILY' RESPONSES COMBINED AS A PERCENTAGE
Science Reform Indicators	23	Uses major concepts (e.g.; systems, change, models, patterns) to focus learning	62.2	56.5
	24	Emphasizes the research process within an integrated framework (e.g.; exploring a topic, planning how to study it and carrying out a study, judging the results, and reporting)	26.4	40.2
	25	Uses substantive content for the course and grade level	92.3	77.8
	26	Uses inquiry-oriented instruction	42.6	63.3
	27	Uses activity-based instruction, engaging students in the doing and learning of science	70.3	58.6
	28	Structures opportunities for students to discuss real-world problems and issues as they relate to the science content	48.1	51.8

An analysis of open-ended responses from students indicated the following themes pertaining to science reform indicators: more labs, higher-level content, required independent learning, incorporated application of knowledge, incorporated connections with real-world/relevant issues, and utilized the application of more technology. In addition, observational data found strategies observed in the category of science reform indicators to be the second highest percentage (28%) of strategies observed, following general teaching strategies. Observational findings and collapsed percentage findings of teachers and students concur that the category of science reform indicator items followed general teaching strategies in terms of implementation frequency, yet exceeded the other three categories of practices.

Research Question #3: What are the specific gifted education instructional strategies being employed by AYGS science teachers?

This question examined the instructional behaviors addressed in Items 1-22 of the surveys and classroom observation forms, specifically general teaching strategies, problem-solving strategies, critical thinking strategies, and metacognition. Since frequent usage as indicated by 90% of respondents (both

teachers and students) is the criterion for determining if a strategy is being employed by science teachers in specialized schools for the gifted, then not a single item in the gifted education strategies was being routinely employed by instructors in AYGS in Virginia. However, teachers and students indicated that strategies were being frequently utilized, but not in 90% or more of the participating classrooms. Some strategies fell slightly below the 90% qualification, while other strategies fell far below. A closer examination of frequent implementation follows below.

In the category of general teaching strategies, the only item in which teachers indicated a 'frequent' use of the strategy (96.4%) was Item 28 - emphasizes higher level thinking skills. For this item, 71.4% of the students indicated frequent usage by teachers. The following items in the category of general teaching strategies saw between one-half and three-quarters of the teacher and student respondents indicating frequent usage of the item: presents lessons in several ways (68.6% of teachers and 52.9% of students); application of knowledge to new situations (70.4% of teachers and 56.6% of students); student use of technology (83.7% of teachers and 68.9% of students); use of hands-on approaches (75.9% of teachers and 72.1% of students); cooperative or collaborative learning strategies (51.0% of teachers and 50.1% of students); students discover ideas through activities/questions (51.8% of teachers and 62.4% of students). Finally, only

approximately one-third of both teachers (38.9%) and students (36.2%) indicated frequent use of flexible grouping strategies.

Not a single item in the category of problem-solving strategies received a frequently used percentage at 90% or greater. In fact, only one strategy, item 11 - uses activities/questions which allowed students to develop, select, implement solutions to problems, had one-half of the participants indicating frequent usage (50.0% of teachers and 54.4% of students). For following items, less than one-half of the respondents indicated frequent usage of the strategy: allow students to brainstorm ideas or alternative (44.4% of teachers and 50.3% of students); allow students to define problems (38.6% of teachers and 52.8% of students); allow students to explore multiple interpretations (24.1% of teachers and 43.0% of students); allow students to use alternative modes of expression (37.1% of teachers and 35.6% of students). Finally, an extremely low percentage of teachers (11.1%) and students (20.9%) indicated frequent use for item 14 - uses activities or questions which allow students to self-select topics for further investigation.

Similarly, not a single item in the category of critical thinking strategies received a frequently used percentage at 90% or greater. In addition, not a single item had over one half of both teacher and students indicating frequent usage of the strategy. Two strategies had just over one-half of the teachers indicating

frequent use, but less than half of the students: provides opportunities for comparing and contrasting (58.5% of teachers and 48.6% of students); opportunities for student to generalize from specific data to the abstract (51.9% of teachers and 37.6% of students). The three remaining items in the category had less than one-half of both teachers and students responding with frequent usage of the strategy: opportunities for students to make judgments/evaluations (37.3% of teachers and 45.9% of students); opportunities for students to synthesize information across disciplines (48.1% of teachers and 42.6% of students); opportunities for students to debate points of view (24.0% of teachers and 37.0% of students).

Finally, the category of metacognition received low percentages from both teachers and students indicating frequent usage. Not a single item received a frequent usage rating from more than 50% of the participating teachers or students. Each of the three items had teachers indicating less frequent usage of the strategy than students: models metacognitive strategies (27.4% of teachers and 32.3% of students); opportunities for students to think about their thinking (34.6% of teachers and 45.0% of students); opportunities for students to reflect on their own performance (42.5% of teachers and 44.5% of students).

Table 18 below addresses the research question examining the usage of different gifted education instructional strategies on a regular basis (weekly and

daily responses of '5' and '6'), with instructors' and students' responses for those frequency counts collapsed as a percentage.

Table 18

Instructors' and Students' Responses for Weekly and Daily Frequencies of Gifted Education Instructional Strategies Collapsed as a Percentage

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	INSTRUCTORS' 'WEEKLY' & 'DAILY' RESPONSES COMBINED AS A PERCENTAGE	STUDENTS' 'WEEKLY' AND 'DAILY' RESPONSES COMBINED AS A PERCENTAGE
General Teaching Strategies	1	Uses flexible patterns of grouping students when delivering a lesson	38.9	36.2
	2	Presents the lesson in several ways	68.6	52.9
	3	Provides activities for students to apply knowledge to new situations	70.4	56.6
	4	Provides the opportunity for students to use technology	83.7	68.9
	5	Uses hands-on approaches, such as journals, experiments, & manipulatives	75.9	72.1
	6	Uses cooperative or collaborative learning strategies	51.0	50.1
	7	Allows students to discover central ideas on their own through activities and/or questions	51.8	62.4
	8	Emphasizes higher level thinking strategies/skills	96.4	71.4
Problem Solving Strategies	9	Uses activities or questions which allow students to brainstorm ideas or alternatives	44.4	50.3
	10	Uses activities or questions which allow students to define problems	38.6	52.8
	11	Uses activities or questions which allow students to develop, select, and implement solutions to problems	50.0	54.4
	12	Uses activities or questions which allow students to explore multiple interpretations	24.1	43.0
	13	Uses activities or questions which allow students to use alternative modes of expressions for their work (charts, graphs, videos, art, music, journals, etc)	37.1	35.6

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	INSTRUCTORS' 'WEEKLY' & 'DAILY' RESPONSES COMBINED AS A PERCENTAGE	STUDENTS' 'WEEKLY' AND 'DAILY' RESPONSES COMBINED AS A PERCENTAGE
Critical Thinking Strategies	14	Uses activities or questions which allow students to self-select topics for further investigation	11.1	20.9
	15	Provides opportunities for students to make judgments or evaluate situations or issues	37.7	45.9
	16	Provides opportunities for students to compare and contrast	58.5	48.6
	17	Provides opportunities for students to generalize from specific data to the abstract	51.9	37.6
	18	Provides opportunities for students to synthesize or summarize information across or within disciplines	48.1	42.6
	19	Provides opportunities for students to debate points of view or develop arguments to support ideas	24.0	37.0
Metacognition	20	Models metacognitive strategies such as planning, monitoring, self-reflection or self-appraisal for the student	27.4	32.3
	21	Provides opportunities for students to think about their own thinking	34.6	45.0
	22	Provides opportunities for students to reflect on their own performance	42.5	44.5

An examination of open-ended responses from students indicated themes pertaining to general teaching strategies: application of knowledge and utilized the application of more technology. Open-ended themes did not encompass strategies found in the other categories: problem-solving strategies, critical thinking strategies, and metacognition. The observational data echoed these findings with

the highest percentage of observed behaviors occurring in general teaching strategies (40%) and the lowest percentage of observed behaviors occurring in metacognition (4%). Percentages of observations for problem-solving strategies and critical thinking strategies were 16% and 12% respectively.

Research Question #4: With what frequency do teachers in specialized secondary schools report using science reform instructional initiatives; with what frequency are instructional strategies for the gifted reportedly employed by these teachers?

The data that link to this research question are the frequency of reported responses given by instructors to the 28-item survey. In most areas, instructors indicated frequency values of 3 - 6 (3 = once every couple of months, 4 = once or twice a month, 5 = at least once a week, 6 = daily), seldom responding with values of 1 or 2 (1 = not at all, 2 = a few times a year). Their self-report levels of implementation indicate they view themselves as using these strategies from once every couple of months to daily.

Overall, teachers viewed themselves as implementing most of the strategies on at least an annual basis; categories with highest frequency counts amongst the most teachers were general teaching strategies and science reform indicators. Only in the category of metacognitive strategies was there an indication that instructors

viewed themselves as not implementing these strategies as often as other strategies, perhaps just a few times a year. It is interesting to note that while teachers view themselves as most often implementing high level thinking strategies, they also indicate low frequency ratings on critical thinking skills, problem-solving strategies, and metacognition.

Student frequency data, and to some extent observational data, confirm teachers' indications of frequency of strategy implementation; most frequent indications were in implementation of general teaching strategies and science reform indicators. Statistical analysis of the frequencies reported by instructors and students indicated that no significant difference exists between instructors' perceptions of instructional strategy implementation and students' perceptions of instructional strategy implementation. However, the fact that all students' responses were grouped together and all teachers' responses were grouped together may have masked some extreme differences between individual teacher responses when compared to his/her students' responses.

A comparison of teacher frequency responses per behavior and the mode of his/her students' frequency responses per behavior was conducted to further investigate the congruency between perceptions of behavior implementation. Teacher responses and the mode value of his/her students' responses were loaded

into a database. If the students' responses did not have a mode or had multiple modes, the median value was used for comparison. If a teacher did not provide a frequency response of a behavior, that behavior for that teacher did not figure into the final analysis of results. Comparisons were made between teacher values and students' values; a difference between values greater than one was noted as non-congruent. A level of congruency was determined for each behavior across teachers. Tallies were also made to determine if differences in responses were occurring for a particular teacher or school.

The results of linking each teacher's response with his/her students' responses were similar to the overall chi-square analysis of teachers' and students' responses. In the category of general teaching strategies, all behaviors had 80% or greater congruency between teachers' responses and their students' responses, with Item #1, flexible patterns of grouping, and Item #7, allowing students to discover the central idea on their own through activities and questions, having the least congruency at 80% each. Similarly, the category of problem-solving strategies had all items with 80% or greater congruency between teachers and their students, except for Item #11, uses activities or questions which allow students to develop, select, and implement solutions to problems, which had 70% congruency. Likewise, the category of critical thinking had 80% or greater congruency on all items except

Item #19, provides opportunities for students to debate points of view or develop arguments to support ideas, which had 67% congruency.

The next category, metacognition, saw less congruency between teachers' and students' responses. The most congruency was found in Item #22, opportunities for students to reflect on their own performance (74%). Next, Item #21, opportunities for students to think about their own thinking, had 60% congruency. Finally, Item #20, models metacognitive strategies such as planning, monitoring, self-reflection or self-appraisal for the student, was the least congruent (47%). This category, metacognition, showed the least amount in congruency of responses overall.

Finally, the category of science reform indicators had all items with 80% or more congruency except Item #24, emphasizes the research process, and Item #26, uses inquiry-oriented instruction, which each had 73% congruency.

Table 19 below shows the level of congruency between teachers' responses compared to their students' responses for each instructional behavior.

Table 19

Congruency Percentage Between Teachers' Reported Frequency Values and Their Students' Reported Frequency Values

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	CONGRUENCY PERCENTAGE
General Teaching Strategies	1	Uses flexible patterns of grouping students when delivering a lesson	80
	2	Presents the lesson in several ways	85
	3	Provides activities for students to apply knowledge to new situations	91
	4	Provides the opportunity for students to use technology	98
	5	Uses hands-on approaches, such as journals, experiments, & manipulatives	98
	6	Uses cooperative or collaborative learning strategies	81
	7	Allows students to discover central ideas on their own through activities and/or questions	80
	8	Emphasizes higher level thinking strategies/skills	89
	9	Uses activities or questions which allow students to brainstorm ideas or alternatives	84
Problem Solving Strategies	10	Uses activities or questions which allow students to define problems	80
	11	Uses activities or questions which allow students to develop, select, and implement solutions to problems	70
	12	Uses activities or questions which allow students to explore multiple interpretations	85
	13	Uses activities or questions which allow students to use alternative modes of expressions for their work (charts, graphs, videos, art, music, journals, etc)	80
	14	Uses activities or questions which allow students to self-select topics for further investigation	81

CATEGORY	ITEM #	INSTRUCTIONAL BEHAVIOR	CONGRUENCY PERCENTAGE
Critical Thinking Strategies	15	Provides opportunities for students to make judgments or evaluate situations or issues	80
	16	Provides opportunities for students to compare and contrast	87
	17	Provides opportunities for students to generalize from specific data to the abstract	81
	18	Provides opportunities for students to synthesize or summarize information across or within disciplines	84
	19	Provides opportunities for students to debate points of view or develop arguments to support ideas	67
Metacognition	20	Models metacognitive strategies such as planning, monitoring, self-reflection or self-appraisal for the student	47
	21	Provides opportunities for students to think about their own thinking	60
	22	Provides opportunities for students to reflect on their own performance	74
Science Reform Indicators	23	Uses major concepts (e.g.; systems, change, models, patterns) to focus learning	80
	24	Emphasizes the research process within an integrated framework (e.g.; exploring a topic, planning how to study it and carrying out a study, judging the results, and reporting)	73
	25	Uses substantive content for the course and grade level	95
	26	Uses inquiry-oriented instruction	73
	27	Uses activity-based instruction, engaging students in the doing and learning of science	91
	28	Structures opportunities for students to discuss real-world problems and issues as they relate to the science content	80

For all of the 28 items, the students' responses were of higher value (more frequent usage perceived) than the teachers' responses in 60% or more of the non-

congruent cases (cases with a difference in value greater than one). In other words, if there was a difference in how a teacher and his/her students perceived implementation of a behavior, the students tended to perceive the behavior more often than the teacher felt like he/she implemented it.

In terms of analysis of congruency on an individual teacher level, each non-congruent item (differences between frequencies greater than one) was tallied for each teacher. The range of non-congruent items was from 0 to 15, with the average being 5 non-congruent items (17.8%); this would indicate there was an average congruency between the teacher and his/her students of 82.2%. Similarly, examination of results at the school level did not show any one school has having more or less congruency than any other school.

Research Question #5: What relationship exists between students', teachers', and outside observers' perceptions of science instruction in advanced science courses at AYGS?

Lack of significant difference between student-reported frequencies and teacher-reported frequencies of strategy implementation suggests that teachers feel they are implementing strategies at a similar frequency with which students perceive that the strategies are implemented. Observational data provided findings

that suggest teachers are implementing general teaching strategies at perhaps a higher frequency than would be expected. Given that there were more behaviors to observe in that category, observations still showed that 40% of the observed behaviors fell into general teaching strategies, when the expected percentage would be closer to 28% implementation. Similarly, observations showed slightly higher usage of science reform indicators (28%) than the expected usage (21%). However, observations showed lower than expected usage of problem-solving strategies (16% observed vs. 21% expected), critical thinking strategies (12% observed vs. 18% expected), and metacognition (4% observed vs. 11% expected).

Only in one of the science reform indicators, more specific in substantive content usage, was implementation observed in all 39 classroom observations. This particular strategy was rated the most used across the student participants and was rated the second most used strategy by teacher participants. Most teachers felt that they used higher thinking strategies most often, while students felt this was the third most used strategy. Observations indicated this behavior was only witnessed 11 out of 39 possible times (28%). For students' second most frequently used strategy, hands-on approaches, teachers indicated its use as their fourth most frequently used strategy. Observational data showed this strategy was used only 12 out of 39 possible observations (31%).

Overall, all three data sources report higher frequencies in the implementation of general teaching strategies and science reform indicators, with lower frequencies of implementation in metacognitive strategies. Both critical thinking and problem-solving strategies frequency reported from teachers and students indicated usage on a monthly periodic basis, with observational findings supporting a less frequent use of these strategies as well. In addition, student open-ended responses indicated themes that strongly link to science reform indicators and, to a lesser extent, general teaching strategies, with no or little mention of items relating to critical thinking, problem-solving, and metacognition.

Summary

Instructor and student perceptions of the implementation of various instructional strategies were gathered through three similar instruments: an instructor 28-item survey, a student 28-item survey, and a classroom observation form with the same 28-item checklist. Comparisons between these instruments using chi-square analysis suggested that instructors and students similarly perceive implementation of these strategies; no significant differences exist between the two groups' perceptions. Within these frequency findings, both students and instructors suggested that general teaching strategies and science reform

indicators were implemented on a more routine or daily basis, critical thinking and problem-solving strategies were implemented on a periodic monthly basis, while metacognitive strategies occurred in the classroom less often. Observational data and student-open ended responses supported these findings.

When an examination of individual teacher's responses were compared to their students' responses, most items not in the metacognitive category showed high levels of congruency (a difference in response of one or less), usually at 80%. Only in the category of metacognition (Items #20, 21, and 22) were the congruency levels considerably lower at 47%, 60%, and 74% respectively.

Closer examination of the instructional strategies teachers employ on a frequent basis (weekly or daily) across the majority of participating teachers and schools (90% indicating frequent use) revealed that not a single science reform indicator or gifted education strategy was perceived as being implemented regularly at that level by both teachers and students. On one finding, over 90% of the teachers indicated frequent usage of the science reform indicator, Item 25 - substantive use of content, but students did not concur. This high level of implementation was supported by observational data. On another finding, over 90% of the teachers indicated frequent usage of the gifted education strategy under the category of general teaching strategies, Item 8 - higher level thinking strategies,

but students did not concur. This high level of implementation was also not supported by observational data.

When student response data were subdivided by school location (urban versus rural) and by teacher professional background (content mastery versus pedagogical certifications), chi-square analyses indicated significant differences in the way these subdivided groups of students perceived teacher implementation of various strategies. Findings indicated, in general, that students of both urban schools and students of content mastery teachers tended to acknowledge instructional use of strategies at a higher frequency than chi-square expected frequency values would anticipate. While this was certainly not the case in each of the 28-items, the strongest difference could be found in the category of general teaching strategies for both subdivided groups, with both the urban school students and the students of content mastery teachers viewing strategy implementation at a higher level than their counterparts. Similarly, in the categories of critical thinking and science reform indicators, urban students indicated more frequent use than their counterparts. Likewise, students of content mastery teachers indicated more frequency of strategy usage in the area of metacognition than expected.

Table 20 below summarizes the research questions addressed by this study and their findings.

Table 20***Research Questions and Their Findings***

RESEARCH QUESTION	DATA SOURCE	FINDINGS
1. How do science teachers' instructional practices vary by the following demographics: urban vs. rural location; fulltime vs. shared-time programs; teacher content area mastery vs. pedagogical mastery; science ability vs. general academic ability as entry criteria for students?	<ul style="list-style-type: none"> • Directors' Surveys • Instructors' Surveys • Students' Classroom Surveys 	<ul style="list-style-type: none"> ✓ Urban vs. rural location: no significant difference in teacher frequency indications; rural students indicated less frequent implementation than expected & urban students indicated more frequent implementation than expected. ✓ Fulltime vs. shared-time programs: not examined as only two programs were full-time ✓ Teacher content area mastery vs. pedagogical mastery: no significant difference in teacher frequency indications; students of pedagogical teachers indicated less frequent implementation than expected & students of content mastery teachers indicated more frequent implementation than expected; overall, most students' differences occurred in general teaching strategies. ✓ Science ability vs. general academic ability as entry criteria for students: not examined as all but one school indicated science ability as criterion for admissions and school focus

RESEARCH QUESTION	DATA SOURCE	FINDINGS
2. What are the specific science instructional reform initiatives being employed by science teachers in specialized schools for the gifted?	<ul style="list-style-type: none"> • Science and Gifted Education Classroom Observation Form • Instructors' Surveys – collapsed data • Students' Classroom Surveys – collapsed data 	<ul style="list-style-type: none"> ✓ If frequent usage as indicated by 90% of respondents (both teachers and students) is the criterion for determining if a strategy is being employed by science teachers in specialized schools for the gifted, then not a single item in the science reform indicators was being routinely employed. ✓ Observational data found strategies observed in the category of science reform indicators to be the second highest percentage of strategies observed, following general teaching strategies. ✓ More students and teachers indicated the use of substantive content as the most frequently used science reform indicator, with both groups indicating that the use of research skills was the least used science reform indicator. ✓ More open-ended student responses fell into this category of science reform indicators; indicating increased use of these strategies over traditional science courses.

RESEARCH QUESTION	DATA SOURCE	FINDINGS
3. What are the specific gifted education instructional strategies employed by AYGS teachers?	<ul style="list-style-type: none"> • Science and Gifted Education Classroom Observation Form • Instructors' Surveys-collapsed data • Students' Classroom Surveys-collapsed data 	<ul style="list-style-type: none"> ✓ If frequent usage as indicated by 90% of respondents (both teachers and students) is the criterion for determining if a strategy is being employed by science teachers in specialized schools for the gifted, then not a single item in the gifted education categories was being routinely employed. ✓ Observational data indicated the highest number of observations in general teaching strategies, with metacognitive strategies least observed. ✓ Collapsed frequency data from teachers and students indicated the category of general teaching strategies as the most used/observed by respondents, with metacognitive strategies least used by respondents. ✓ More students and teachers indicated the use of higher order thinking skills as the most frequently used strategy, with both groups indicating that allowing students to self-select topics for further investigation was the least used gifted education reform indicator.

RESEARCH QUESTION	DATA SOURCE	FINDINGS
4. With what frequency do teachers in specialized secondary schools report using science reform instructional initiatives; with what frequency are instructional strategies for the gifted reportedly employed by these teachers?	<ul style="list-style-type: none"> • Science and Gifted Education Classroom Observation Form • Instructors' Surveys • Students' Classroom Surveys 	<ul style="list-style-type: none"> ✓ Most teachers rated themselves as using strategies a couple of times a month to using them daily; seldom did teachers indicate less frequent usage of strategies. ✓ The strategy indicated by teachers as frequently used by the most teachers was higher level thinking strategies. ✓ The strategy indicated by teachers as least used by the most teachers was allowing students to self-select topics for further investigation. ✓ Chi-square analysis of teachers' frequency responses and students' frequency responses showed no significant difference in perceived implementation. ✓ Analysis of frequency responses at the teacher level indicates a high level of congruency between teacher and students except in the category of metacognition.
5. What relationship exists between students', teachers', and outside observers' perceptions of science instruction in advance science courses at AYGS?	<ul style="list-style-type: none"> • Science and Gifted Education Classroom Observation Form • Instructors' Surveys • Students' Classroom Surveys 	<ul style="list-style-type: none"> ✓ All three data sources report higher frequency of implementation of general teaching strategies and science reform indicators, with lower frequency of implementation of gifted education strategies. ✓ Both critical thinking and problem-solving strategies reported from teachers and students indicated usage on a monthly periodic basis, with observational findings supporting a less frequent use of these strategies as well. ✓ Student open-ended responses indicated themes that strongly link to science reform indicators and, to a lesser extent, general teaching strategies, with no or little mention of items relating to critical thinking, problem-solving, and metacognition.

CHAPTER 5

DISCUSSION, CONCLUSIONS, AND IMPLICATIONS

Discussion

The context of the study represents an ideal setting to implement recommendations from both national science reform and gifted education reform efforts. Analysis of study data revealed no significant difference between the instructors' perceptions of the frequency with which they implement both gifted and science instructional strategies and students' perceptions of the frequency with which those strategies occur in advanced science classrooms in specialized schools for the gifted. Examination of frequency data by teacher and their corresponding student population suggests some differences between perceptions may be masked by group analysis in the area of metacognition. Evidence suggests that implementation of these reform strategies is occurring at some level of frequency, although statistical chi-square analysis does not account for the differences that could be occurring on the individual classroom level. Both the quantitative and qualitative data support the fact that students in AYGS science classes are receiving, with limited frequency, instructional practices that align with recommendations from the *National Science Education Standards* (NRC, 1996) and

the *National Excellence Report* (OERI, 1993). Perhaps more in question is the limited frequency with which these practices are being employed in a sample of specialized secondary schools for the gifted, most of which focus on science learning.

Results from this study indicated that three categories of instructional strategies are extremely underutilized: problem-solving strategies, critical thinking strategies, and metacognitive strategies. Other research studies found that these categories of instructional practices are most closely aligned with student achievement in the discipline of science (Shymansky, Kyle, and Alport, 2003; Wenglinsky, 2000; Cuccio-Shirripa and Steiner, 2000; and Von Secker and Lissitz, 1999). The findings of this study suggest that gifted students in specialized secondary schools are not receiving perhaps the most important strategies linked to student achievement. While these gifted secondary students may do well in future endeavors, the question arises as to how much more they could achieve if they were receiving more frequent exposure to instructional strategies linked to problem-solving, critical thinking, and metacognition.

Another interesting finding relating to the use of this critical thinking and metacognitive strategies is the fact that teachers indicated a high level of utilization of higher level thinking strategies within the category of general teaching strategies. Yet, these same teachers rated themselves as extremely low in

utilization of the use of critical thinking strategies and metacognition. This disparity in implementation frequency would indicate that teachers might not perceive higher level thinking strategies as the specific strategies listed under critical thinking and metacognition. Another explanation might be that teachers are aware of the fact that they are supposed to be implementing higher level thinking strategies in the classroom so they simply indicated their implementation. In either case, these findings suggest more targeted staff development in critical thinking instructional strategies and metacognitive instructional strategies.

Closer examination of qualitative student responses and frequency counts from instructors and students reveal some additional findings. Many of the qualitative student responses highlight the fact that teachers are individuals and, as such, view curriculum and instructional practices differently. These differences were noted by students in their open-ended responses as to the difference in the use of instructional practices at their home high schools versus the courses at the Governor's School. Occasionally, students would mention that another teacher in the Governor's School was better, or worse, at implementing a variety of instructional approaches. This is consistent with other research that indicates the key role of the teacher in implementing gifted instructional practices (VanTassel-Baska, 1992; VanTassel-Baska, 1995, VanTassel-Baska, Bass, Reis, Poland, Avery, 1998; Gallagher,

Stepien, & Rosenthal, 1992). Although the qualitative data were not reviewed or analyzed at an individual instructor's level, there were a few classrooms of students who rated a teacher particularly high or low on all items, confirming the key role the individual teacher has in implementing instructional strategies. The key role individual teachers play in the classroom in a study by Wenglinsky (2000) illustrated the impact of classroom practices on student achievement.

This study also examined the percentage of students and teachers in the study that perceived the implementation of strategies on a weekly or daily basis. Given the context of the study, the percentage of expected responses of teachers and students (90%) at that level of implementation was not indicated for a single strategy. Even at the category level of implementation, only two areas, science reform indicators and general teaching strategies, had students and teachers indicating daily or weekly strategy usage in the majority of strategies at levels of 50% or greater. Again, this finding raises concern over the underutilization of instructional strategies linked to student achievement in science.

Whether the 90% implementation from both groups of participants at a strategy-level of analysis is realistic or not is subject to discussion. Other readers of the study might suggest 85% usage by teachers and students would be more realistic; again, results would not indicate frequent usage even at that level. Some

readers might suggest that collapsed data should include the rating of '4' - once or twice a month; the researcher felt this would be too limited to indicate routine or frequent usage of a strategy. These schools/classrooms should be expected to implement these strategies on a daily or weekly level across 90% of the participants; after all, these are specialized schools for the gifted with a focus toward science education. Analysis of strategies implantation during 30-minute observations shows an average use of five strategies per teacher, with the range of usage being one - 17. The average strategy usage of five strategies per 30-minutes would suggest that all 28 strategies could be used at least once over the course of one week.

In terms of instructional practices that stress science education reform, the study provided evidence suggesting that some strategies were frequently used, and other strategies were implemented to a lesser degree. Frequency counts from teachers and students, as well as observational data, indicated the frequent use of substantive content, the use of activity-based instruction, engaging students in the learning and doing of science (hands-on activities), relating science to real-world issues, and the use of inquiry-oriented instruction.

In the strategy dealing with use of concepts to focus instruction, teachers rated themselves as using the strategy "daily," while students suggested usage of this strategy at a "weekly" level and observations suggested usage at an "annual" or

bimonthly level." Teachers' indications of the use of research methods suggested use at the "monthly level," while students indicated usage at the "weekly level" and observations indicated a "bimonthly" usage. The inconsistencies between groups for these science reform indicators warrant further research.

Further, themes from students' open-ended responses suggest that these advanced courses offer more labs, more hands-on activities, substantive and challenging content, connections to the world around them, and, most importantly, 'it is the best science course they had ever taken.' Given that most of these students were in their final years of schooling, these statements might indicate the lack of use of reform strategies in elementary and middle school, and even early high school, science courses. Even though implementation of these reform strategies were reportedly underutilized in this study, students still felt that low level of implementation was more than they had received prior to taking a course at the Governor's School. Implications for research and staff development at elementary and middle schools are certainly evident.

From the gifted education perspective, the lack of significant differences in instructors' and students' responses and the overall low frequency counts given to individual strategies similarly implies that gifted education strategies are being implemented to a minimal degree. Observational data reveal that while most of the

strategies relating to general teaching and problem-solving strategies occur occasionally, those strategies associated with critical thinking and metacognition were occurring at a very low frequency of implementation. Student and teacher weekly and daily frequency percentages of implementation suggest that problem-solving, critical thinking, and metacognitive strategies are occurring regularly in less than 50% of the sampled teachers' classrooms. Unfortunately, studies indicate the importance of these strategies to student achievement and to the achievement of science reform (Wenglinsky, 2000; Von Secker & Lissitz, 1999; Taconis, et. al., 2001; Goodman & Bernston, 2000; Cuccio-Schirripa & Steiner, 2000; Shymansky, et. al., 2003). Thus the underutilization of these is disheartening.

Staff development findings revealed that less opportunity for professional development in gifted education exists at the school level, and that instructors attend fewer gifted education-related events outside of the school setting. Studies by Leberman (1999), van Driel, et. al. (2001), Suporitz & Turner (2000), and Davis (2003) stress the importance of staff development and training to the implementation of inquiry and constructivist methodologies. Lower attendance at and provision of staff development opportunities in gifted education may account for the less frequent use of these strategies across the sample population, a situation that needs to be changed.

Finally, the analysis of students' ratings of urban school teachers vs. rural school teachers and students' ratings of content mastery teachers vs. teachers with pedagogical certification provided some interesting findings. Students from urban schools indicated implementation of strategies in a more positive light, indicating they felt strategies were used more often than statistical expectations might suggest. Similarly, students of content mastery teachers indicated that they saw strategies implemented more frequently than would be statistically expected. Both groupings indicated higher frequency of strategy use than their counterparts. This was particularly interesting when closer examination revealed that the greatest differences in values were seen in the areas of general teaching strategies, metacognition, and in some items of the science reform indicators. While content mastery teachers might be expected to do better in the category of science reform indicators, students' perceptions indicated that urban teachers and content mastery teachers did better in the more pedagogical categories of general teaching strategies and metacognition than did their counterparts. One rationale for these findings might be that students of content mastery teachers are so impressed with their teacher's knowledge of the subject matter that they tend to perceive more frequent implementation of instructional strategies.

Conclusions

Findings from this study indicate that instructors of advanced science classes in secondary schools for the gifted are occasionally implementing nationally recognized gifted education and science education instructional strategies, but not at a level of frequency that would suggest they routinely implement the strategy. Both students and instructors concur that these strategies are being implemented in the classroom setting at relatively low frequency. There was no significant difference between instructors' perceptions of the frequency of implementation of instructional strategies and students' perceptions of the frequency of implementation of instructional strategies; however, when the data were sub-analyzed for congruency between individual teacher responses and their students' responses, there were differences in the category of metacognition. When individual classes were sub-analyzed using a 80% threshold of congruency between teacher and student responses, metacognitive strategies were below the threshold level, with Item #20 at 47% congruence, Item #21 at 60% congruence, and Item #22 at 74% congruence.

However, closer examination of the frequency counts from students and teachers indicate that not all teachers are implementing strategies with the same degree of frequency. In fact, not a single science or gifted education strategy was

perceived as frequently utilized (weekly or daily) by at least 90% of the participating teachers and students. Some strategies had 25% or less of participants indicating that they were frequently used (weekly or daily). This is disheartening given the strong linkage between strategy implementation and student achievement. Perhaps these gifted students are not achieving in science at the level they could be if these reform strategies were being implemented on a routine basis?

Practical Implications of the Study

For the field of science education and gifted education, the implications of this study are striking. While participating teachers at specialized secondary schools for the gifted tend to be strong in terms of professional credentials in their content area of science, they have fewer credentials in the area of gifted education. Concerns may arise as to the ability of these instructors, while they understand science, to implement nationally recommended practices of instruction in both science and gifted education. With few routine opportunities for staff development in both science and gifted education, it is understandable that implementation of these reform strategies might be infrequent.

Since all teacher participants were science educators in specialized secondary schools for the gifted (most schools with a focus in science education), the

expectation that all or even 90% of teachers would be implementing these strategies on a weekly or daily basis is practical. Evidence to support this expectation was lacking. However, all strategies dealing with science reform indicate more prevalent usage on a weekly and daily basis than gifted education strategies. In addition, findings from both the directors' surveys and instructors' surveys would suggest that staff development opportunities are attended and offered less often in the area of gifted education. Providing more in-service workshops and supporting conference attendance or college courses in gifted education may strengthen the implementation of the less frequently practiced instructional gifted education categories of problem-solving, critical thinking, and metacognition. Specialized schools for the gifted should strive to increase staff development offerings in the area of gifted education practices.

In general, this study suggests the development of more formal staff development programs in science and gifted education, specifically dealing with reform instructional strategies from both fields. The use of the *SGECO* form as an evaluation tool for expected teacher behaviors could be incorporated formally into the teacher evaluation instrument. Based on the needs of teachers in certain schools, a review of the *SGECO* form and the implementation patterns for their school, specific workshops could be developed to target the implementation of

specific strategies. Teachers in those schools that are proficient in those strategies may serve as peer-coaches in follow-up activities. In the initial hiring of teachers, the strategies suggested in the *SGECO* form may serve as a basis for selecting instructors for teaching positions, based on teaching observations using the form.

For these specialized secondary schools for the gifted, this study suggests that instructor evaluation forms incorporate a closer examination of these instructional strategies as part of the teacher evaluation process, whether it is formally incorporated or not. The use of the *SGECO* form as a tool for examining individual teacher strengths and weaknesses in the area of instructional practices would certainly be appropriate.

Some implications exist for higher education institutions in teacher training in the use of both science education and gifted education instructional reform strategies. While making pre-service teachers aware of the specific strategies examined in this study is important, providing opportunities in the program for these teachers to practice and employ these reform strategies is vital.

Implications of the Study for Future Research

This study suggests topics for future research that pertain to the implementation of instructional practices in science education and gifted education.

Where both students and instructors concur on the implementation frequency of instructional strategies from both fields, a limited number of classroom observations were available to support claims. A stronger number of classroom observational findings would provide a more defensible perspective on this issue.

Still the question remains, what would be the proper frequency with which these strategies should be used? This study showed the percentage of participants indicating weekly or daily usage of all the strategies under investigation. Since the criterion level of 90% of the participants was not met for any strategy, perhaps this expectation was too high. However, the criterion level would seem to be justified based on the type of school and the level of use required for routine practice. Perhaps course curriculum, especially more structured formats such as Advanced Placement courses (AP), may be impacting these findings and expectations for implementation. A recent study for the National Research Council (NRC, 2002) found that Advanced Placement science and math courses were not geared to provide students with exposure to research-based strategies. Further investigations could examine the use of science and gifted strategies as they relate to particular science disciplines, to particular course curriculum like AP science courses, and to teacher training and staff development.

Even though the expectation that 90% of participants would recognize strategy use as weekly or daily, qualitative remarks from students indicated that these classrooms were different and offered more opportunities associated with these science and gifted education strategies than other courses they took at their home high school or middle school. While this study was conducted at the secondary level, certainly research into instructional practices at the middle school and elementary school gifted science classroom settings to assess reform-based strategy implementation would be appropriate and warranted.

Taking the research a step further, investigations into classrooms where students, teachers, and observations support daily and weekly use of these strategies would provide additional insights. What factors make this situation a reality? How does the frequent (weekly and daily) use of these strategies impact student achievement in areas other than standardized tests?

Regardless of the focus of the future research, more research into classroom practices is necessary. At a time of national educational reform and standardized testing, it is the classroom practices that make a difference for students; that inspires their love of learning and desire to pursue their interests. If we are to teach students to think for themselves, to become tomorrow's leaders, we must

provide thinking and learning opportunities in classrooms through the implementation of strong and effective instructional strategies.

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APPENDIX A

ACADEMIC-YEAR GOVERNOR'S SCHOOLS IN STUDY

GOVERNOR'S SCHOOL	DIRECTOR	ADDRESS	MEMBERSHIP FORMAT
A. Linwood Holton Governor's School	John Collier jcollier@swcenter.edu	SW VA Higher Ed. Center VA Highlands Comm. College P.O. Box 1987 Abingdon, VA 24212	Grades 10-12; multiple sites; limited science courses
Blue Ridge Governor's School	Karen Wormley brvgs@hotmail.com	P.O. Box 419 Palmyra, VA 22963-0419	Grades 9 +; multiple sites; limited science courses
Central Shenandoah Valley Governor's School for Science, Mathematics, and Technology	Linda Cauley lcauley@csvrgs.k12.va.us	Augusta County Public Schools Route 3, Box 265 Fishersville, VA 22939	Grades 11-12; single site; a variety of science courses
Central Virginia Governor's School for Science and Technology	Thomas Morgan (Dr.) tmorgan@cvgs.k12.va.us	3020 Wards Ferry Rd Lynchburg, VA 24502	Grades 11-12; single site; a variety of science courses
Chesapeake Bay Governor's School for Marine and Environmental Science	Patricia Griffin pgriffin@oonl.com	Essex County Public Schools P.O. Box 756 Tappahannock, VA 22560	Grades 11-12; multiple sites; limited science courses
Commonwealth Governor's School	Sylvia Wadsworth swadsworth@cgs.k12.va. us	Regional Administrative Offices 6713 Smith Station Rd. Spotsylvania, VA 22553	Grades 9-12; multiple sites; a variety of science courses
Governor's School for Global Economics and Technology for Southside Virginia	Catherine Cottrell cathycottrell2001@yaho o.com	200 Daniel Road Keysville, VA 23947	Grades 11-12; multiple sites
Maggie L. Walker Governor's School for Government and International Studies	Doug Hunt dhunt@gsgis.k12.va.us	1000 North Lombardy Street Richmond, VA 23220-2204	Grades 9-12; single site; a variety of science courses
Jackson River Governor's School	Susan Rollinson (Dr.) dlrolls@dl.cc.va.us	Dabney S. Lancaster CC P.O. Box 1000 Clifton Forge, VA 24422	Grades 11-12; single site; limited science courses

GOVERNOR'S SCHOOL	DIRECTOR	ADDRESS	MEMBERSHIP FORMAT
New Horizons Governor's School for Science and Technology	Donna Poland dpoland@nhgs.tec.va.us	520 Butler Farm Road Hampton, VA 23666	Grades 11 -12; single site; a variety of science courses
Roanoke Valley Governor's School for Science and Technology	Shirley Whorley swhorley@rvgs.k12.va.us	2104 Grandin Road SW Roanoke, VA 24015	Grades 9-12; single site; a variety of science courses
Southwest Virginia Governor's School for Science, Mathematics, and Technology	Margaret (Pat) Duncan duncan@swvgs.k12.va.us	Pulaski County Public Schools, P.O. Box 1739 Dublin, VA 24084	Grades 11-12; single site; a variety of science courses
Thomas Jefferson High School for Science and Technology	Elizabeth Lodal elodal@lan.tjhsst.edu	6560 Braddock Road Alexandria, VA 22312	Grades 9-12; single site; a variety of science courses

APPENDIX B

LETTER OF PARTICIPATION

Dear Director and Science Instructor,

My name is Donna Poland and I am a doctoral candidate at the College of William and Mary. My purpose in writing you today is two fold. First, I would like to inform you about my dissertation research. Secondly, I want to ask your permission to include you in my study. All aspects of this research have been approved by the W & M Human Subjects Review Board and found to be in compliance with all aspects of educational research; names and information will remain confidential and you may opt out of the study at any time.

I am conducting my dissertation research on instructional strategies used by science instructors in Governor's School across the Commonwealth of Virginia. I am asking that each site director complete a Director Survey Form. In addition, I would appreciate it if at least 5 science teachers, in any advanced level science courses such as biology, chemistry, physics, and/or earth/environmental science, would participate in the study by completing the Instructor Survey Form. These advanced courses should be designed for 11th and 12th grade students. It is important that each director and participating science teacher signs the attached permission form and completes the appropriate Director or Instructor Survey Form. In addition, I am requesting a course syllabus from each participating instructor.

Enclosed is a copy of the Student Survey Form. Please have all advanced science students in the participating teachers' appropriate advanced science courses complete the student survey form. Student parental consent forms are included if the director feels they are necessary. Please group student responses with their corresponding teacher and return all forms and materials by the indicated date in the provided envelope.

For six of the AYGS, I will be conducting site visits to observe participating teachers in their classrooms. If your school has been selected as one of the observational sites, I will be contacting you by phone to set up a site visit.

All data will be analyzed in strict confidence; no school or individual will be mentioned by name in the final report. Copies of the final report will be made available to participants upon request (please email dpoland@nhgs.tec.va.us to request a copy). My sincere appreciation for your support in this educational endeavor.

Sincerely,

Donna L. Poland

APPENDIX C

PARTICIPANT CONSENT FORM

I, _____, give my consent to participate in a dissertation study conducted through the College of William and Mary by Donna Poland. I understand that participation in the study will require completion of survey forms by myself, completion of survey forms by my students, the provision of a course syllabus, and, possibly, a classroom observation by Ms. Poland, my director, or an appointed assistant observer.

Participant Signature _____

Date _____

Thank You Very Much!

APPENDIX D

DIRECTOR'S SURVEY

School Demographic Information: Site Name _____

Number of students in program: _____

Educational focus of AYGS: _____

School location: _____ urban _____ suburban _____ rural

Student selection criteria (check all that apply):

_____ GPA _____ Strong academic background in science and/or math

_____ PSAT _____ teacher recommendations in science and/or math

_____ SAT _____ other standardized test score

_____ Extra Curricular Activities

_____ Division selection - no or little input by Gov. School

Define your role: _____

Number of years in this position at this site: _____ **other sites:** _____

Your degree level and focus: BS _____

MS _____ PhD/EdD _____

Additional training in gifted education: (Check all that apply)

_____ *Course Work* _____ *Endorsement* _____ *Formal Degree at Master's level*

_____ *Formal Degree at Doctorate level* _____ *Other* _____

Additional training in science education: (Check all that apply)

☐ *Course Work* ☐ *Endorsement* ☐ *Formal Degree at Masters level*
☐ *Formal Degree at Doctorate level* ☐ *Other* _____

Questions:

1. How are science teachers/faculty selected at this school? (Check all that apply)

☐ Based on a resume that meets minimum requirements of teaching certification ☐ Faculty has MS degree in education or science field
☐ Faculty are selected by local college; site has no control ☐ Interview with selection committee
☐ As part of the interview, faculty must demonstrate knowledge of teaching skills for the selection committee ☐ Faculty are selected by local school divisions; site has no control
☐ Other, explain: _____

2. What two educational goals serve as the major foci for instruction at your school?

3. What documentation is used to evaluate teachers'/faculty's instructional practices? (Please include documentation with other materials when returning this survey).

☐ no methods are used ☐ checklist/teacher classroom observation form ☐ teacher portfolio
☐ scripted teacher classroom observation form ☐ video and discussion of classroom practices ☐ Other: _____

4. How often have you offered staff development in science over the past three years? (Check only one)

<input type="checkbox"/> not at all	<input type="checkbox"/> one session annually	<input type="checkbox"/> 2-4 sessions annually
<input type="checkbox"/> 5-7 sessions annually	<input type="checkbox"/> 8+ sessions annually	<input type="checkbox"/> Other: _____

5. What specific instructional practices have been highlighted through those inservices? (Check all that apply)

<input type="checkbox"/> integrating technology	<input type="checkbox"/> project-based work	<input type="checkbox"/> inquiry approach
<input type="checkbox"/> questioning strategies	<input type="checkbox"/> problem-solving	<input type="checkbox"/> interdisciplinary perspectives
<input type="checkbox"/> concept mapping	<input type="checkbox"/> hands-on approaches	<input type="checkbox"/> grouping strategies
<input type="checkbox"/> Problem-based Learning	<input type="checkbox"/> developing inquiry-based labs	<input type="checkbox"/> Other: _____

6. How often have you offered staff development in gifted education over the past three years? (Check only one)

<input type="checkbox"/> not at all	<input type="checkbox"/> one session annually	<input type="checkbox"/> 2-4 sessions annually
<input type="checkbox"/> 5-7 sessions annually	<input type="checkbox"/> 8+ sessions annually	<input type="checkbox"/> Other: _____

7. What specific instructional practices have been highlighted through those inservices? (Check all that apply)

- | | | |
|---|--|---|
| <input type="checkbox"/> integrating technology | <input type="checkbox"/> project-based work | <input type="checkbox"/> inquiry approach |
| <input type="checkbox"/> questioning strategies | <input type="checkbox"/> problem-solving | <input type="checkbox"/> interdisciplinary perspectives |
| <input type="checkbox"/> concept mapping | <input type="checkbox"/> hands-on approaches | <input type="checkbox"/> grouping strategies |
| <input type="checkbox"/> Problem-based Learning | <input type="checkbox"/> developing inquiry-based labs | <input type="checkbox"/> Other: _____ |
| | | _____ |

8. What role do you play in providing instructional guidance to teachers/faculty?

- | | | |
|--|---|---|
| <input type="checkbox"/> none | <input type="checkbox"/> available upon teacher request to discuss instructional issues | <input type="checkbox"/> periodically set up meetings with faculty to discuss instructional methods |
| <input type="checkbox"/> Teach a class for the instructor as a model for instructional practices | <input type="checkbox"/> regularly teach a course at the school | <input type="checkbox"/> determine all staff development and inservice opportunities dealing with instruction |
| <input type="checkbox"/> dedicate funds for teacher travel to professional conferences | <input type="checkbox"/> conduct classroom observation and provide critique | <input type="checkbox"/> Other: _____ |
| | | _____ |
| | | _____ |

APPENDIX E

INSTRUCTOR'S SURVEY

Site: _____

Position: _____ No. years in position at site: _____ other sites: _____

Total years teaching: _____ Total years teaching science: _____

Total years working with academically gifted students _____

Current grade level assignment _____

Current course assignment(s) _____

Your degree level and focus: BS _____

MS _____ PhD/EdD _____

Special certificates or endorsements: _____

Additional training in *Science Education* in the past 3 years:

___ none

___ school sponsored
teacher inservice

___ school sponsored
teacher workshops

___ attendance at
local/national conferences

___ mentor/peer guidance

___ college or organization
sponsored teacher workshops

___ additional college/univ.
courses

___ faculty meetings to
discuss science education

Other: _____

Additional training in *Gifted Education* in the past 3 years:

___ none

___ school sponsored
teacher inservice

___ school sponsored
teacher workshops

___ attendance at
local/national conferences

___ mentor/peer guidance

___ college or organization
sponsored teacher workshops

___ additional college/univ.
courses

___ faculty meetings to
discuss gifted education

Other: _____

This questionnaire reflects instructional practices used in _____ course.

With what frequency do you use the following instructional strategies when teaching this course?

Please assign a frequency value of 1-6 from the scale below to each strategy.

1 = not used at all

2 = a few times a year

3 = once every couple months

4 = once or twice a month

5 = at least once a week

6 = daily

1. ____ Uses flexible patterns of grouping students when delivering a lesson
2. ____ Presents the lesson in several ways
3. ____ Provides activities for students to apply knowledge to new situations
4. ____ Provides the opportunity for students to use technology (Please indicate frequency of calculator use ____; computer use ____; advanced science equipment use ____)
5. ____ Uses hands-on approaches, such as journals, experiments, & manipulatives
6. ____ Uses cooperative or collaborative learning strategies
7. ____ Allows students to discover central ideas on their own through activities and/or questions
8. ____ Emphasizes higher level thinking strategies/skills
9. ____ Uses activities or questions which allow students to brainstorm ideas or alternatives
10. ____ Uses activities or questions which allow students to define problems
11. ____ Uses activities or questions which allow students to develop, select, and implement solutions to problems
12. ____ Uses activities or questions which allow students to explore multiple interpretations
13. ____ Uses activities or questions which allow students to use alternative modes of expressions for their work (charts, graphs, videos, art, music, journals, etc)
14. ____ Uses activities or questions which allow students to self-select topics for further investigation
15. ____ Provides opportunities for students to make judgments or evaluate situations or issues
16. ____ Provides opportunities for students to compare and contrast
17. ____ Provides opportunities for students to generalize from specific data to the abstract
18. ____ Provides opportunities for students to synthesize or summarize information across or within disciplines

19. ____ Provides opportunities for students to debate points of view or develop arguments to support ideas
20. ____ Models metacognitive strategies such as planning, monitoring, self-reflection or self-appraisal for the student
21. ____ Provides opportunities for students to think about their own thinking
22. ____ Provides opportunities for students to reflect on their own performance
23. ____ Uses major concepts (e.g.: systems, change, models, patterns) to focus learning
24. ____ Emphasizes the research process within an integrated framework (e.g.: exploring a topic, planning how to study it and carrying out a study, judging the results, and reporting)
25. ____ Uses substantive content for the course and grade level
26. ____ Uses inquiry-oriented instruction
27. ____ Uses activity-based instruction, engaging students in the doing and learning of science
28. ____ Structures opportunities for students to discuss real-world problems and issues as they relate to the science content

Other Comments:

APPENDIX F

STUDENT CLASSROOM SURVEY

Site: _____

Years attending this school: _____ **Current grade level** _____

Current science courses _____

This questionnaire reflects instructional practices used in _____ **class.**

1. What expectations do you have for the instructional practices in this class?

2. With what frequency does your teacher use the following instructional strategies when teaching this course?

Please assign a frequency value of 1-6 from the scale below to each strategy.

1 = not used at all 2 = a few times a year 3 = once every couple months

4 = once or twice a month 5 = at least once a week 6 = daily

1. ____ **Uses flexible patterns of grouping students when delivering a lesson**
2. ____ **Presents the lesson in several ways**
3. ____ **Provides activities for students to apply knowledge to new situations**
4. ____ **Provides the opportunity for students to use technology (Please indicate frequency of calculator use ____; computer use ____; advanced science equipment use ____)**
5. ____ **Uses hands-on approaches, such as journals, experiments, & manipulatives**
6. ____ **Uses cooperative or collaborative learning strategies**

7. ____ Allows students to discover central ideas on their own through activities and/or questions
8. ____ Emphasizes higher level thinking strategies/skills
9. ____ Uses activities or questions which allow students to brainstorm ideas or alternatives
10. ____ Uses activities or questions which allow students to define problems
11. ____ Uses activities or questions which allow students to develop, select, and implement solutions to problems
12. ____ Uses activities or questions which allow students to explore multiple interpretations
13. ____ Uses activities or questions which allow students to use alternative modes of expressions for their work (charts, graphs, videos, art, music, journals, etc)
14. ____ Uses activities or questions which allow students to self-select topics for further investigation
15. ____ Provides opportunities for students to make judgments or evaluate situations or issues
16. ____ Provides opportunities for students to compare and contrast
17. ____ Provides opportunities for students to generalize from specific data to the abstract
18. ____ Provides opportunities for students to synthesize or summarize information across or within disciplines
19. ____ Provides opportunities for students to debate points of view or develop arguments to support ideas
20. ____ Models metacognitive strategies such as planning, monitoring, self-reflection or self-appraisal for the student
21. ____ Provides opportunities for students to think about their own thinking
22. ____ Provides opportunities for students to reflect on their own performance
23. ____ Uses major concepts (e.g.: systems, change, models, patterns) to focus learning
24. ____ Emphasizes the research process within an integrated framework (e.g.: exploring a topic, planning how to study it and carrying out a study, judging the results, and reporting)
25. ____ Uses substantive content for the course and grade level
26. ____ Uses inquiry-oriented instruction
27. ____ Uses activity-based instruction, engaging students in the doing and learning of science
28. ____ Structures opportunities for students to discuss real-world problems and issues as they relate to the science content

3. How do the instructional practices in this class compare to other science courses you have taken? If another science course has been better taught, please describe the level and type of class and its site location. (Please indicate type of school middle, high, summer Governor's School, private, etc.)

4. Other comments?

APPENDIX G

PARENT LETTER AND STUDENT CONSENT FORM

Dear Parent and Student,

My name is Donna Poland and I am a doctoral candidate at the College of William and Mary. My purpose in writing you today is two fold. First, I would like to inform you about my dissertation research. Secondly, I want to ask your permission to include you in my study. All aspects of this research have been approved by the W & M Human Subjects Review Board and found to be in compliance with all aspects of educational research; names and information will remain confidential and you may opt out of the study at any time.

I am conducting my dissertation research on instructional strategies used by science instructors in Governor's School across the Commonwealth of Virginia. I will be examining strategies used in advanced science courses for 11th and 12th grade students. All science students in the participating teachers' appropriate advanced science courses will complete a student survey form. The form asks for some basic demographics on the student and the student's perception of the use of certain instructional strategies in the classroom. Completion of the survey form will be all that is required of your child from this study.

All data will be analyzed in strict confidence; no school or individual will be mentioned by name in the final report. Copies of the final report will be made available to participants upon request (please email dpoland@nhgs.tec.va.us to request a copy). Please sign and return the bottom portion of this form to your child's teacher if you are willing to have your child participate in this study. My sincere appreciation for your support in this educational endeavor.

Sincerely,

Donna L. Poland

I give my consent for my child, _____, to participate in a dissertation study conducted through the College of William and Mary by Donna Poland. I understand that my child will only be required to complete a survey form that will remain anonymous. In addition, I understand that my child's name will never be used and he/she may opt out of the study at any time.

Parent's Signature _____ Date _____

APPENDIX H

SCIENCE AND GIFTED EDUCATION CLASSROOM OBSERVATION FORM

Observer _____ Site _____

Date _____ Course _____ Instructor _____

Number of students _____

Desk arrangement: _____ rows and columns _____ grouped _____ lab tables

_____ other: please specify _____

Please outline exactly what you are observing in the classroom with respect to curriculum and instruction. Describe the specific lesson, the organization of the lesson, the texts and/or materials used, the methods used in communicating the lesson, characteristics of the learning experience and the environment, and any other observations or impressions.

Teacher Interview Questions: (to be conducted after the observation)

1. Do you have a written plan for the lesson?
2. What were your instructional objectives during the previous lesson with this class?
3. What will you be covering in the subsequent lesson?
4. Are there any aspects of this lesson that you want to clarify with me before I finalize the observation form?
5. Observer specified question: _____

Observer will indicate the presence of a behavior with a check mark [✓].
Observation should last approximately 30 minutes.

CATEGORY	ITEM #	OBSERVED?	OBSERVATION START TIME : <input type="text"/>	OBSERVATION COMPLETION TIME : <input type="text"/>
			Behavior	
General Teaching Strategies	1		Uses flexible patterns of grouping students when delivering a lesson	
	2		Presents the lesson in several ways	
	3		Provides activities for students to apply knowledge to new situations	
	4		Provides the opportunity for students to use technology: <input type="checkbox"/> Y <input type="checkbox"/> N calculator <input type="checkbox"/> Y <input type="checkbox"/> N computer <input type="checkbox"/> Y <input type="checkbox"/> N advanced science equipment	
	5		Uses hands-on approaches, such as journals, experiments, & manipulatives	
	6		Uses cooperative or collaborative learning strategies	
	7		Allows students to discover central ideas on their own through activities and/or questions	
	8		Emphasizes higher level thinking strategies/skills	
Problem Solving Strategies	9		Uses activities or questions which allow students to brainstorm ideas or alternatives	
	10		Uses activities or questions which allow students to define problems	
	11		Uses activities or questions which allow students to develop, select, and implement solutions to problems	
	12		Uses activities or questions which allow students to explore multiple interpretations	
	13		Uses activities or questions which allow students to use alternative modes of expressions for their work (charts, graphs, videos, art, music, journals, etc)	
	14		Uses activities or questions which allow students to self-select topics for further investigation	

Critical Thinking Strategies	15	Provides opportunities for students to make judgments or evaluate situations or issues
	16	Provides opportunities for students to compare and contrast
	17	Provides opportunities for students to generalize from specific data to the abstract
	18	Provides opportunities for students to synthesize or summarize information across or within disciplines
	19	Provides opportunities for students to debate points of view or develop arguments to support ideas
Metacognition	20	Models metacognitive strategies such as planning, monitoring, self-reflection or self-appraisal for the student
	21	Provides opportunities for students to think about their own thinking
	22	Provides opportunities for students to reflect on their own performance
Science Reform Indicators	23	Uses major concepts (e.g.; systems, change, models, patterns) to focus learning
	24	Emphasizes the research process within an integrated framework (e.g.; exploring a topic, planning how to study it and carrying out a study, judging the results, and reporting)
	25	Uses substantive content for the course and grade level
	26	Uses inquiry-oriented instruction
	27	Uses activity-based instruction, engaging students in the doing and learning of science
	28	Structures opportunities for students to discuss real-world problems and issues as they relate to the science content

APPENDIX I

STUDENT RESPONSES TO OPEN-ENDED QUESTIONS

The following responses to the stated questions represent the most common themes expressed by students in science classes in AYGS throughout Virginia. These responses were gleamed from approximately 1190 student surveys. However, about 1/3 of the students did not respond to one or more of the questions. Again, these are representative of the answers given by students.

1. What expectations do you have for the instructional practices in this class?

- College level content in 'the subject area'.
- Prepare me for college.
- Prepare me for the AP exam.
- To be taught in an environment that is exciting and conducive to learning.
- I expected the course to challenging and the instructor to be knowledgeable of the subject.
- I expect to learn the basic principles of 'the subject' hands-on experiments, along with taking notes. I expect the material to be challenging without being impossible.
- I expect my teacher to teach me the best way possible. I hope to learn based on labs, lecture, and other interesting ways.
- My teacher to have a high level of enthusiasm/motivation towards the subject material . . . keeping and maintaining discipline, order, but providing a stimulating learning environment w/open discussion; flexible; advocate for creativity; integrated work.

- Hands-on learning experiences that involve labs and group activities, as well as participation, and flexible yet efficient lesson plans.
- To be able to understand what's happening in the world.
- Fun learning experiences centered around high level content.
- Having taken GS courses before, instructional practices would be independent learning and a lot of learning would be done outside of school . . . basic concepts would be taught, but more advanced concept learning would come with individual effort and discovery.
- No expectations.

3. How do the instructional practices in the class compare to other science courses you have taken? If another science course has been better taught, please describe the level and type of class and its location. (Please indicate type of school middle, high, summer Governor's School, private, etc.)

- This course is better than all my other courses because we have to come prepared for class with homework we haven't talked about yet. This gives us a chance to learn things on our own and then ask questions instead of being force-fed the answers.
- Learning is interactive and the course is made up of intellectually challenging activities. Also, the class runs at a faster pace.
- It is the right mixture of discussion, debate, PowerPoint, projects, and class work.
- More labs than any of my other science courses.
- High-level content that applies to real-world situations.
- All of the other science courses I have taken just teach everyone from a plan, even if they already know it. This class allowed students

to ask questions about what they don't know so that there is no time wasted teaching students something they already know.

- The instruction is laughable. The class is difficult, but not in ways that encourage learning or challenge students to try.**
- Actually, I think this is the best taught science course I've ever had . . . the instructor is creative, encourages us to think-outside-the-box, and apply concepts to our daily lives.**
- This class' instructional practices differ from most science classes I have previously taken. Most others were very routine and did not place much emphasis on the actual scientific study. However, with weekly labs and activities, this class presents much better the actual methods of science.**
- This and all the classes at this same site show a rigorous learning environment where the student is initiated in the learning process at school and then is engaged in further study of concepts on their own time and then that information is brought back to the class to get the overall backbone of the lesson or concept.**
- I have taken 3 Gov. School science classes. All of the classes have presented challenge and have integrated lab activities and technology to improve instruction.**
- This year, I feel like I, and my fellow students, have been thrust into a situation that requires us to teach ourselves. Our teacher presents the information in what seems like the most difficult way possible we have to sift through the rhetoric to find the answer. In my previous experiences, I was presented the information I needed. I don't think this is a reflection of the school as much as it is the teacher.**
- This class is being taught much better than any of my most recent science courses. Science is usually taught to us through video or a lecture. In my current science class, experiments, hands-on activities, and discussion with our teacher helps me learn much easier.**

- Other science classes have been "memorize this for the SOL." This class has been "learn this and apply it." This class is a nice change from "regular school".
- Much more lecturing compared to other classes.
- The teacher is always willing to help you understand.
- It is the best class I have ever taken, material wise, but unfortunately, due to the necessary preparation for the AP, we have to rush through the material, which makes me feel like it is concentrated in my short-term memory and I am not learning anything that will stick.
- The science class does not compare to any other science course I have taken. The elevated learning and independence does not compare with my home school science courses. I am grateful for the experience. I feel thoroughly prepared for college next year.
- This class has been much better compared to the teaching methods in other science courses that I have taken. I can actually apply what I learn here and make my own inferences instead of taking and digesting information, spitting it back out on a test, and not remembering or applying the information until I have to take a standardized test.
- The instructional practices in this class have been above average compared to former classes I have taken. I think that the use of technological equipment has helped the learning process by giving hands-on experiences that help prove theories. I also think the teaching is challenging in that the information is not spoon-fed to the students, but students are given the opportunity to find answers on their own.
- More versatile, a little less structured. I am more free to learn here without being bound with notes and worksheets. We get to express our own opinions and debate important issues. We also have labs; the class is very hands-on. Like the Chinese proverb says, "You hear - you

forget, you see - you remember, you do - you learn" (. . .or something of that nature)!

- This is a higher-level college course.
- About the same as other courses I've taken.
- Our instructor is very effective in causing us to reflect upon our role in the environment and the world. Instead of a 'grade factory', we are taught to flex our minds to encompass the new and unexpected. Our instructor is not afraid to keep us in line and on our toes.
- This course is very rigorous. The structure of the class combined with the genius teacher always keeps the students challenged. There is so much more opportunity to apply what is taught in class here at this school as oppose to science classes at my home school.
- This is by far one of the most in-depth science courses I have taken. I feel that it requires more intellectual thought and reasoning as compared to the memorization done in high school level courses. Because of this, I am glad to be taking (subject) here at (school). It allows for in-depth discovery of the science, while at the same time, it provides the guidance needed for a misunderstood subject.
- In my sophomore year of high school, I took an honors chemistry class in which: real world data was incorporated, independent learning was expected, outside thorough research was rewarded as well as assigned, class discussions revolved around real world applications, the class was not changed or abridged to suit those incapable of operating at that specific level, students were required to memorize almost every aspect of a subject, students were rewarded for independent abstract thought in the form of problem solving. I took this class in at high school in New Jersey.

Question 4 was open-ended for student to write whatever comments they

wanted to make. Rarely was this question answered. Of the few comments that

were made, most pertained to the format of the survey; with many students commenting that they did not completely understand the question or the terms, especially the word metacognition. Some answers were blanket comments about whether they liked or disliked the teacher. Below are the few student comments that were unique . . . and perhaps, insightful.

4. Other comments?

- Not only is the content of the course helpful, but the whole atmosphere at the Gov. School cultivates learning. That is, were the teachers plucked out of the Gov. School and placed in a normal school, the quality of the education would still not be as high. This has to do with the administration as well as the school atmosphere - at the Gov. School, teachers are allowed to be flexible; while at the normal high school, teachers dislike the rigid, incompetent administration.
- I believe that such classes are pertinent to the development of the advanced mind. Often, courses given at a local public school do not challenge those who truly can reason a subject and apply it and not just memorize simple laws and theories.
- The doors for this excellent opportunity should be opened to everyone who wants to learn, not mainly the 3.8, 3.9, 4.0 GPA students. If every student were given the chance to be challenged and interested in their academic life, there would be a greater opportunity for them to succeed in life.
- I realize that since this class is AP, we don't necessarily have time to do 'fun' activities since we have a set curriculum to cover. However, sometimes learning so much in one day can be mentally draining. Students need a change to discussion or an activity ever so often. But

nevertheless, I am benefiting from all the material we learn and I know that it will prepare me well for the AP exam.

- The questions in this survey seem like they were written for a humanities class. Many of the examples are simply not feasible or applicable in a science setting.
- Some of these questions don't demonstrate the quality of a science class. We don't need to debate points of view, and it won't help us to learn to evaluate situations or issues. Also, there's so much material to learn, we don't have the option to divide topics and self-select what we want to study - we have to learn everything.
- Some of the questions are very difficult to apply to a science class, i.e. #13, music, art, and journals are not typically a part of any scientific learning, which focuses on fact, not individual interpretation or reflection.
- This was not a survey that made sense. Some things can't be scaled by daily or monthly use.
- Uses activity-based instruction, engaging students in the doing and learning of science doing of science? You learn it, you explain it, you use it, but you don't 'do it'!

VITA

Donna Lorraine Poland

Birthdate: 2 October, 1957

Birthplace: Savannah, Georgia

Education:

**1995-1997 The College of William and Mary
Williamsburg, Virginia
Education Specialist**

**1993-1994 The College of William and Mary
Williamsburg, Virginia
Master's of Arts in Education**

**1975-1981 North Carolina State University
Raleigh, North Carolina
Bachelor of Science**